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COMMANDER HORACE ELMER, U. S. N., in the Chair.

RANGE LIGHTS ON SEAGOING SHIPS.

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The necessity of changing the present system of lighting ships has long been apparent, and is growing more urgent every day, owing to the constant increase of ocean travel. It is no longer sufficient simply to know that a red light to starboard, or a green light to port, indicates the position of a vessel heading in such an indefinite direction that she may, or may not, be crossing your course. For safety in navigation something more definite is demanded. With the great speed of modern steamers, ships must be lighted so that their course and movements may be shown at night with as much accuracy, if possible, as during the day. In devising means to accomplish this object it must be borne in mind that, when emergencies arise, the memory is not always to be depended upon, and any system of signals requiring the mind, under such circumstances, to reason from cause to effect will always be more or less unreliable. Even with the present side lights it is only after long experience, upon sighting a colored light, that one remembers, without reflection, that red means

port and green starboard, and thus forms a mental picture of a ship in the position indicated by the light. If, in addition to the colored light, signals are made, the meaning of these signals must also be recalled to memory; and when they indicate a change of helm or movement of the vessel, the effect which follows them, not being visible to the eye, must be applied to the mental picture already formed. Thus, under the influence that an unseen danger inspires, and with confusing data to bear in mind, errors will inevitably occur.

It is sought to reduce to a minimum the mental process by which the heading and the movements of a ship are determined, thus leaving the judgment unembarrassed. The necessity of forming a mental picture must be avoided and the unseen danger brought plainly in view. The proposition to place two lights on each side of a ship is a step in this direction, but it is doubtful that the small advantages obtained by any of these systems are sufficient to outweigh the disadvantages of carrying two additional lights.

To avoid collision successfully under all circumstances there is required: 1. The position of your vessel in regard to the heading of the other; 2. Any change of that vessel's course; 3. Her approximate speed. By day the heading of a ship and change of her course are indicated by the appearance of her masts and hull, and the speed is estimated from the character of the vessel and the rapidity with which her bearing changes; but at night these conditions must be shown by means of lights. The idea involved in the following proposed system is to so place three lights on a ship that she will be lighted all around the horizon, and her heading and every change of her course will be more plainly indicated at night by means of these lights than is indicated during the day by the appearance of the ship itself. We shall first consider the system in its simplest form, and then such modifications as may be deemed necessary to accomplish the desired object.

LIGHTS.

1. Every seagoing ship, whether a sailing ship or a steamship, shall carry, forward of the foremast, two bright white lights of the same character as the present masthead light of steamships, visible five miles on a clear night, and showing an unbroken light from right ahead to two points abaft each beam. These two lights shall be in the vertical plane of the keel, and placed with the lower light forward of the upper light, so that for a vertical distance of ten (10) feet

between the lights there will be a horizontal distance of fourteen (14) feet, or in the proportion thereof—*i. e.*, a line through the two lights will make an angle of fifty-five (55°) degrees with the vertical.

2. Every seagoing ship, whether a sailing ship or a steamship, shall carry at the stern one bright white light so fixed as to show an unbroken light from right astern to two points forward of each beam. With lights placed as above, the direction in which any ship is heading, and every change of that direction, will be plainly indicated by the relative position of the two forward lights, as will be seen by the following explanation.

When right ahead of another ship, her two forward white lights will be seen, one directly above the other. On the starboard bow of that vessel her lower light will be open to the right of her upper light, and on her port bow her lower light will be open to the left of her upper light—*i. e.*, on her starboard bow an imaginary line through her two lights will incline to the left from the vertical, and on her port bow it will incline to the right from the vertical. The amount of the inclination of the lights of that vessel from the vertical indicates your position on her bow; thus: From right ahead her lights will be seen in a vertical line.

1 point	on her bow	their inclination	will be	1½	points	(15° 25′).
2 points	"	"	"	"	2½	"	(28° 25′).
3	"	"	"	"	"	3½	"	(39° 22′).
4	"	"	"	"	"	4	"	(45°).

To estimate the inclination of the lights by the eye to within 11° (one point of inclination), or even more, is quite accurate enough for all practical purposes. We may therefore disregard the fractional parts of a point in estimating the inclination of the lights. Then, your bearing on the bow of any vessel will be the same as the number of points the lights of that vessel are inclined from the vertical. If you bear more than four points on the bow of another vessel, the lights of that vessel will be inclined more than four points, or 45°. At six points on that vessel's bow her stern light will be visible. If you bear between two points forward of her beam and two points abaft her beam, her two forward lights and her one stern light will be visible. From two points abaft the beam on one side to two points abaft the beam on the other side, the stern light alone of that vessel will be visible. The diagram, Fig. 1, illustrates through what arcs the lights of any vessel will show, and how much a line joining the two forward lights will appear inclined from the vertical at different positions on her bow.

When two vessels are meeting end on, each will see the lights of the other in a vertical line, so that any change of the course, or of the bearing, may be instantly detected by observing that the lower light opens to the right or left of the upper light. When two vessels are crossing, each ship will see the lights of the other inclined from the vertical. *C* being two points on the port bow of *D*, he will see two white lights on *D* inclined about two points to the right from the vertical. *D* being four points on the starboard bow of *C*, he will see two white lights on *C* inclined four points (45°) to the left from the vertical. From two points forward of the beam to two points abaft the beam, on both sides, all three of the lights will be visible.

To test the practical working of this system, lights were placed in position on a steam launch. At a distance when the lights were just visible and with but eight feet in the vertical between them, the heading of the launch was plainly indicated, and every change of course was at once easily detected. At given signals made by occultations of the light, four observers on the ship estimated independently the heading of the launch. Of over fifty observations on various courses the greatest single error was but one and one-half points, part of which was, no doubt, due to the error of the boat's compass, which was not ascertained. Lights were also placed in position on the ship, and three observers in the launch steamed around at a distance varying from one-half to one mile. Bearings of the launch were accurately taken from the ship, and the result is tabulated below.

Bearings of the Launch on the Ship's Bow.	Estimated Position by Observers in the Launch.	Personal Errors.	Average Error.
55° starboard bow.	48 50 52	7° 5° 3°	½ point.
50° " "	45 40 45	5° 10° 5°	½ "
43° " "	45 30 35	2° 3° 8°	¼ "
25° " "	30 30 20	5° 5° 5°	½ "
6° " "	2 2 2	4° 4° 4°	½ "
21° port "	15 10 15	6° 11° 6°	¾ "
31° " "	40 40 30	9° 9° 1°	½ "
39° " "	40 35 37	1° 4° 2°	¼ "
43° " "	40 40 40	3° 3° 3°	¼ "
50° " "	50 50 50	0° 0° 0°	0 "

Speed signals were also made, and nothing simpler or plainer could be desired. Although these experiments were not made in rough

water, they will serve to show the accuracy of the range under ordinary circumstances.

It may be urged, as an objection to this system of lighting ships, that the rolling or heeling of a ship in a seaway will destroy the range of her lights. In answering this objection, it is necessary to investigate the effect upon the apparent inclination of the lights caused by any motion of the ship. If a ship rolls regularly through equal arcs on each side of the vertical, the angle may still be estimated with sufficient accuracy by noting the centre of the arc through which the lights move. As the motion of the waves and the rolling of the ship are not uniform, there frequently occur intervals when their effect is neutralized and the ship becomes momentarily upright. It requires but little observation to detect these intervals. But any permanent or steady heel will more seriously affect the apparent inclination of the lights than the same amount of rolling. We will first consider the effect upon this inclination when the vessel heels from you or to leeward. Any heeling towards you will apparently place you farther on her bow, but not sufficiently to be misleading.

In the diagram, Fig. 2, A represents the apparent position of the upper light, and B the apparent position of the lower light, when seen from directly ahead. B_1, B_2, B_3, B_4, B_5, and B_6, the apparent position of the lower light when seen from one, two, three, four, and five points on the bow, and abeam; the upper light still appearing at A. A_6, A_1, A_2, A_3, A_4, and A_5, the arcs through which the light A appears to move while the ship heels through 90° when seen from ahead, one, two, three, four, and five points on the bow. The lines AB, AB_2, etc., represent the apparent inclination of the lights when seen from one, two, etc., points on the bow. To find this inclination when the ship is heeled, draw a line through the apparent position of the lower light to the point in the corresponding arc to which the upper light is heeled. Thus, when you are three points on the bow of a ship heeled twenty-five degrees, the apparent inclination will be B_3L instead of B_3A.* In this way it will be seen that when you are six points on a vessel's bow, no matter how much she may roll, her lights can never indicate that you are less than five points on her bow. At five points on her bow her lights can never indicate that you are less than four points. At four points her lights can never make a less inclination than 35° from the vertical, which corresponds to a position of three points on her bow. At three points an improbable steady heel of 25° will still leave the lights inclined 25°,

which corresponds to a position two points on the bow. At two points she will have to be heeled over 35° before the lights will indicate that you are ahead. If she rolls 35° to leeward, or from you, and nothing to windward—an extreme case—her lights will still plainly indicate that you are more than one point on her bow. We see, then, that at two, three, four, five, and six points on a vessel's bow it will hardly be possible to make an error of more than one point due to any heeling or rolling of the ship.

With the present system of lighting ships the colored side lights generally show one-half a point on the opposite bow, and, through carelessness, often more. There is, then, a sector ahead of ships comprised between one-half a point on each bow, within which you cannot tell which bow you are on. This corresponds to the position, under the law, of "end on or nearly end on." No evil effects result from the lights shining across the bow to this limited extent. Knowing that you are in this doubtful sector defines your position with sufficient accuracy to avoid collision. It now remains to determine this "doubtful sector" with the range lights. First, in the case of steamers: during light breezes and a smooth sea there is practically no doubtful sector. With moderate breezes and a moderately rough sea it will be less than that assigned to the colored side lights. In rough weather, when a steamer is rolling heavily, if the average inclination of her lights be estimated with but a fair degree of accuracy, it will still be small. Thus, if you are ahead, and she is rolling as much as sixteen degrees to leeward and nothing to windward, twenty degrees to leeward and but five to windward, etc., you may know from the average inclination that you are within half a point on her bow. Again, if you are one-half a point, say, on her weather bow, she will have to roll more than thirty degrees to leeward and nothing to windward, or maintain a steady, permanent heel of sixteen degrees, before her lights will indicate that you are one-half a point on the opposite bow. Some seagoing steamers cannot maintain a steady heel of more than six or seven degrees, owing to the danger from parts of the boiler becoming unduly heated. It is doubtful if any ship will have occasion to steam along at night with a greater steady heel than ten or twelve degrees. But attention is called to the fact that when a vessel is thus heeling, the cause is evident in the state of the wind and sea, and it requires but little exercise of the judgment to make all necessary allowance for such a case and accordingly act with a greater margin of safety. The same remarks apply to sailing vessels,

and, although the heeling may be more, the amount of the heeling is more evident and certain. If, with a beam wind and sea, you are meeting nearly end on, your true position is to windward of your apparent position by an amount equal to the heel of the ship. For simplicity, assume this amount to be constant and equal to one-half a point in all cases where a vessel should be heeled on account of wind or sea. Then, if extreme heeling causes an error of one point in judging your position (and it can scarcely cause more), you will be but one-half a point from your true position. If you have assumed an extreme heel, and corrected your position accordingly, when in reality no heel existed, you will still be but half a point from your true position.

It has been assumed that the simplicity and evident advantages of carrying but two bright white lights, and the accuracy obtained by their range under all ordinary circumstances, will far outweigh the chances of a possible error under exceptional circumstances. If such does not prove to be the case, there is a simple and effectual remedy that will be shown further on.

Any radical change in the present system of lighting ships meets with the serious and well-founded objection that its introduction, no matter how much of an improvement on the old system, will cause confusion and lead to grave disasters. No such difficulty need be met with in the introduction of the proposed system. The principal steamship lines may be authorized to carry their spare masthead light so that the two will form the assigned range, while the colored side lights are still retained. As the value of the range lights becomes recognized, and their use becomes familiar (their simplicity requiring but one practical demonstration to make them so), the colored side lights may be discontinued. If, after thus giving the system a fair practical trial upon the ocean under all conditions of wind and sea, it is found that the range does not sufficiently define your position in the doubtful sector ahead, the defect can be fully overcome by retaining the side lights. If, then, extreme heeling should cause any doubt as to your position when nearly ahead, you will know that you are within a point or so on that bow of the ship shown by the color of her side light. Such an arrangement requires four lights, but the same result will be obtained by combining the two side lights and the lower white range light into one light fitted with a centre screen so as to show green to starboard and red to port. As the stern light is not absolutely necessary, we shall then have all ships lighted by only two

lights—a white masthead light and a lower colored range light. This is practically no change in the present system of lighting ships. It simply amounts to placing the two side lights on a range with a masthead light. The color of the light performs no part in determining the heading of a ship, but simply serves as a check in estimating your position under exceptional circumstances.

In avoiding collision, owing to the great speed of some modern steamers and the comparatively slow speed of others, speed has become quite as important a factor as the heading or the bearing of a ship. Thus, suppose that from a steamer with a speed of eighteen knots the lights of a steamer with a speed of seven knots are sighted, close by, between three and four points on the starboard bow. The first vessel must keep clear, and her safest way is to keep her course and maintain her speed, while to port the helm or to slow down and attempt to pass astern might be dangerous. Again, suppose the case reversed and the slower steamer sights the faster one five points or even more on her starboard bow; the slower steamer may not be able to pass ahead of the faster one, and yet, not knowing the speed of the latter, she would be justified in attempting it. The same illustration applies when considering the relative heading of another ship.

If the speed of all vessels were the same, there would be but two factors to consider—a vessel's heading and her relative bearing—so that the avoidance of collision could be reduced to a mathematical rule so simple in its practical application as to be almost independent of errors of judgment. But when the third factor of a difference of speed has to be taken into consideration, the problem becomes so complicated that no practical rules can be made applicable to all cases. Such general rules do more harm than good by often lawfully justifying a course which one's judgment regards as dangerous. This was plainly demonstrated by what was known as the "law of the port helm," where the port helm was indiscriminately resorted to in cases of doubt, not so much with the object of avoiding collision as to clear the owner of responsibility. The most that can be done is to furnish at a glance the correct data as to the bearing, heading, and speed of a ship, and then indicate, as the present law does, which vessel shall keep clear of the other.

The most obvious method of indicating a vessel's speed at night is by means of signals, and these signals, like the lights, should be continuous and mechanical in character, and not subject to personal error or negligence in making them. The following means by which this

may be accomplished may appear, upon first thought, to be complicated, but will be found to be simple and practicable, and of invaluable utility for other purposes.

The upper light on steamships is to be so fitted with a guard surrounding the flame that the light will be occulted every half minute a given number of times according to the speed; each occultation lasting one second, with an interval of one second, and the number of occultations to be regulated as follows:

Speed 5 knots, or nearest thereto, 1 occultation every ½ minute.

Speed 10 knots, or nearest thereto, 2 occultations every ½ minute.

Speed 15 knots, or nearest thereto, 3 occultations every ½ minute.

Speed 20 knots, or nearest thereto, 4 occultations every ½ minute.

That is, one occultation for every five knots of speed. The mechanism required to make these occultations may be of the simplest character, occupying but a few inches of space within the lamp. It will cost much less than the lamp itself, and, being less delicate, can withstand rougher usage without injury. It will not be required to keep accurate time, since an error of even ten or fifteen seconds a minute will make no difference in the result. As electrical appliances are now almost universal on board steamers, a small armature and magnet may be placed within the lamp, and the wires led to the bridge or pilot house. There they will be connected with the clock mechanism which completes the circuit the required number of times every half minute, making the occultation as required above. The number of occultations is then under immediate control. By means of a switch and a make-circuit key the speed signals may be discontinued and long and short occultations made according to a devised code of signals. Ships would thus be enabled to communicate with each other at night. Messages could be exchanged by passing steamers, even though their decks were below the horizon, at such distances that flag signals would be invisible. The international signal book would become as useful at night as during the day, and telegraphic signals could be exchanged more rapidly. A rope or stay passing in front of the light will not occult it, and if temporarily obscured by a yard or sail during a heavy roll, the effect would be so entirely different in its character that it could not be confounded with speed signals. The bright white lower range light, powerful enough to be seen ten or fifteen miles, could scarcely be mistaken for a deck lantern or cabin light accidentally exposed. If such were the case, the evil could easily be remedied by occulting the lower light for

speed signals instead of the upper one. In the case of sailing vessels, this possible objection will be considered further on.

The speed of sailing vessels is indicated with sufficient accuracy by the force of the wind. The speed occultations of a steamer's light will, therefore, distinguish her from a sailing vessel.

The present masthead light of nearly all steamers is now carried upon one of the forward stays, and there can be no difficulty in placing the two range lights in their relative positions. The lights can also be readily placed upon sailing vessels, showing clear of all the head sails, and without altering any of the rig. Thus, beneath the foot of the topgallant sail, or royal, or even at the masthead, are positions more suitable than that occupied by many masthead lights at present, which are so low as often to be obscured by sails. If no position on the mast or headstays is found suitable, the light can be placed on a span running fore and aft across the headstays and above the sails. A secure position, making the required angle, can always be found for the lower light beneath the headbooms or on the outer stay. The number of lights required to be carried by seagoing ships may be further reduced: 1. A ship towing another ship shall carry a bright white light similar in character and construction to the masthead light, and placed in the line of the range lights, not nearer than five feet to either of them; 2. A ship not under command shall carry a red light in place of the additional light carried by towing ships, the light to be visible over the same arcs and visible at least two miles; 3. A ship employed in laying or picking up a telegraph cable shall carry a green light in place of the additional light carried by towing ships. When not making headway the ships referred to in 2 and 3 shall not carry the upper white light. As the system now stands, it may be said that it can never be misleading; the objection to colored side lights, except their lack of power, is almost entirely overcome; the number of lights is reduced to a minimum; the speed is indicated and your position determined with all necessary accuracy; all of which may be comprehended at a glance. If this system does not fulfill all the conditions required, it is hoped that its discussion may continue to agitate the problem of lighting ships to avoid collision, and help to arrive at some satisfactory solution.

DISCUSSION.

Lieutenant CHARLES BELKNAP.—*Mr. Chairman and Gentlemen:*—I have listened with a great deal of interest to this paper, for I, with many others, believe that the present system of showing a vessel's position by lights is inadequate to the needs. The plan proposed by Lieutenant Fletcher is ingenious, and admirable in many respects; I do not, however, think that the forward light could be carried by schooners and other vessels of low freeboard in bad weather with any degree of security. Even if they did not, it would not, perhaps, be very different from their common practice at present. But Lieutenant Fletcher makes no distinction between sailing vessels and ordinary steamers, and this I look upon as a serious defect; on the other hand, the plan seems admirably adapted to the use of steamers, especially in a crowded harbor like New York's, and it affords, moreover, an opportunity of getting rid of the green light—a very strong point in its favor.

Lieutenant C. D. GALLOWAY.—*Mr. Chairman and Gentlemen:*—The system of lights suggested by the essayist seems to me to be one possessing many favorable points. That it is a good one in principle is conclusively proved by its successful use by steamers in all of our inland waters; that it could be applied successfully to seagoing vessels there seems to be little doubt. The angle at which they should be placed, as so fully worked out by the essayist, appears to be a very important point in the system.

When the essayist suggests that with his scheme the rule of the road varies with the speed of either vessel, I think he makes a grave mistake. There are so many reasons why the speed of any vessel may vary suddenly and unexpectedly. No variation in the rules should be permitted unless the approaching vessel is in sight long enough for several bearings to be taken, and she be found to be drawing aft or becoming more distant.

As to the determination of speed by flashes, an error of one count in the number of flashes may make an error in speed information of five knots. The most likely place for collisions being at points where many vessels arrive at or about the same time, imagine the officer of the watch with two or three steamers and as many schooners and other sail vessels in sight counting the flashes of each steamer, remembering the knots for each, looking out for his own vessel, and considering whether the rules of the road should be observed literally, or if, in his judgment, the speeds of the approaching vessels warrant a personal departure. I cannot see that this requires further comment. The occulting light for signals, however, might be useful.

The essayist says the lights are to have a range of 5 miles on a clear night, and, in his remarks on the system of occulting, he says the lower light, if powerful enough to be seen 10 or 15 miles, would not be mistaken for any deck light, etc. No light can be placed as low as required by the system and have such a range; it is doubtful whether a 5-mile range could be reached except in a few vessels with exceptionally high freeboard, nor do I think such a range would at all enhance the value of the system.

Referring again to the essayist's remarks on speed, he says that the speed of sail vessels can be calculated by the force of wind; this I have no hesitation in saying is totally unreliable. As with steamers it is not possible to tell, under many conditions of sea and wind, the heading within one or two points, owing to the heel of vessel affecting angle of lights, so, with sail vessels, it will certainly be impossible to tell even the approximate speed by knowing only her approximate heading. So many unknown quantities enter this problem—the rig of the vessel sighted; whether a good model or a bad one; whether light or deep-loaded; whether she has all drawing sail set, or is under easy or jury canvas; whether by the wind or free. A consideration of this impresses me more forcibly that any rule of the road involving speed is radically wrong.

I presume the essayist intends that the occulting of the upper light shall be the distinguishing mark for steam vessels, although he does not say so. I think a colored light—say red—would be much more effective. I say red in preference to any other color, as it is less liable to be mistaken for any other; cheap green shades frequently appear white. And again it is doubtful whether any method of occulting with certainty and precision is practicable on many small steamers, or even large ones. I think with the same lights for both, much more confusion and much greater chance of collision would ensue than with the present red and green side lights and the distinguishing white light for steamers.

The present system can be improved, and it is pleasant to think that a member of the Institute has made such a practical move in that direction. It will call forth many suggestions on the subject from men most interested in lessening the dangers of navigation, the greatest of which to-day is collision; a danger that is increased by the gross ignorance of many seagoing people of the rules of the road, as well as by their gross carelessness in regard to the lights, which if carried at all are frequently neither properly screened nor tended. The recklessness of vessels at sea with regard to lights is known to us all. There seems to be little use of laws on the subject, as there is at present no way of ascertaining the names of vessels seen without lights. Their spars, hulls, or sails are seen and passed, with nothing to indicate even their nationality. Should a collision take place, a lamp of the proper color and size is usually produced at the trial.

The lights suggested by the essayist have the advantage of being easily carried by small vessels, even in bad weather, but with limited range, which is, however, a vast improvement over the present lamp—red on one side and green on the other—which may be flashed up suddenly under one's bows.

Again, referring to the subject of rules of the road, it is a fact that many of the masters of our fore-and-aft coasters think their vessels are on the starboard tack when their starboard sheets are aft, and *vice versa* for the port tack; being without the tacks of square-riggers, they do not understand the proper meaning of the term. With such understanding, of what use are the rules of the road?

I should like to suggest that the pamphlet "Rules of the Road" be issued with every copy of the Hydrographic Chart, and that it be given to every master applying to branch hydrographic offices for any information. And also that

a note be added to the effect that, in interpreting these rules, a vessel is on the starboard tack when the wind blows on starboard side of said vessel, and *vice versa;* and close-hauled when sailing as near to the point from which the wind blows as possible.

While on this subject, I would like to say that in my opinion the limit of two minutes allowed for the fog signals of steamers is too great, even for the "moderate speed" at which they are required to go. For a steamer whose fair-weather speed is from 15 to 18 knots, 10 knots is "moderate speed," at which speed, between the blasts as now allowed, she will go one-third of a mile. Several methods, more or less complicated, have been suggested from time to time by which steamers may indicate their approximate course in thick weather. I would like to add one to these, as from many schemes may be devised one that will fill a long-felt want. As an approximate guide, *one* blast of the steam whistle, repeated at a not greater interval than *one* minute, indicates a course between north and east, including east; two blasts, repeated as above, indicate a course between east and south, including south; three blasts, repeated as above, indicate a course between south and west, including west; and four blasts, repeated as above, indicate a course between west and north, including north. These would no more interfere with the change-of-course signals as used by our river and bay steamers, and allowed by rules of road, than do the single blasts as at present used. This scheme, when on or near the cardinal points, still leaves much uncertainty, but is, I think, an improvement over the present guesswork.

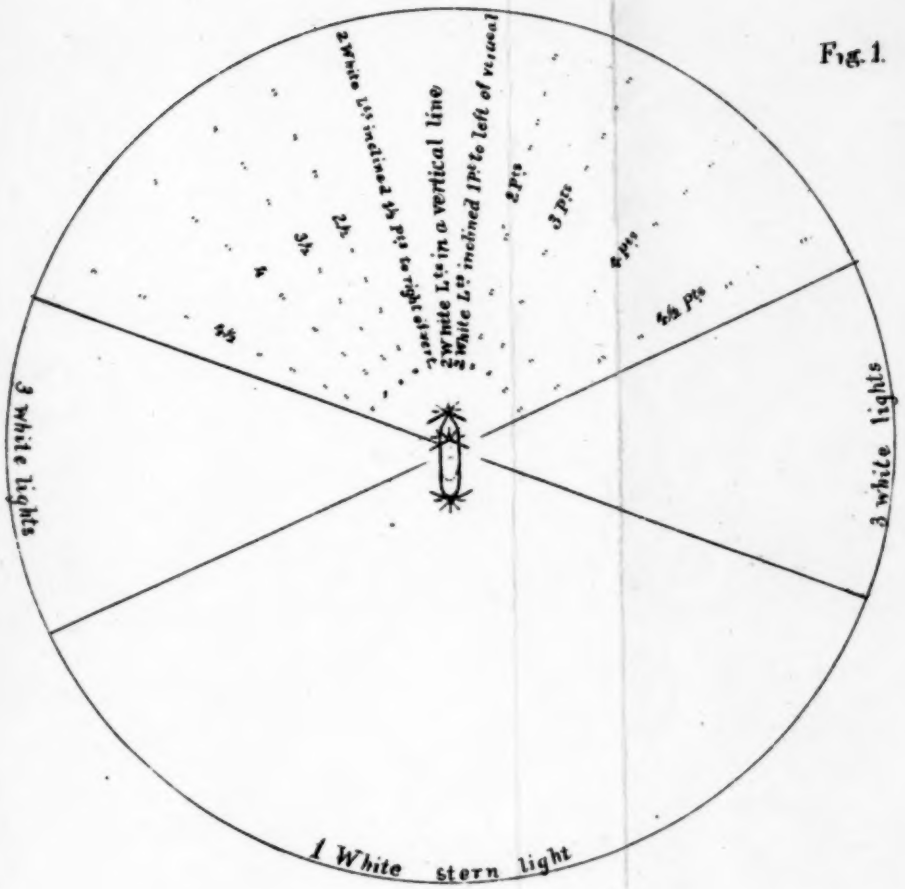
To lessen the dangers of collision, lights, of whatever system, *must* be carried in all weathers from sunset to sunrise, and the rules of the road must be implicitly obeyed.

THE CHAIRMAN.—*Gentlemen:*—I am sure we all agree as to the importance of the subject under discussion this evening. The great increase in size, unhandiness, and speed of modern passenger steamers and vessels of war has made some change in the present system absolutely necessary. The question of speed, in my opinion, is of the greatest importance, and it is the possible wide range in speed that makes some change imperative. As I listened to the reading of the paper this evening, I was strongly impressed with the fear that the essayist was attempting too much. The general discussion that followed has confirmed that impression. The principal difficulty found, however, has been in the application of this system to sailing vessels. I see no necessity for so doing, or changing the present system for sailing vessels. The distinction between the steamer and sailing vessel should be made as sharp as possible. The direction and force of the wind, in connection with the present lights, give the course and speed of sailing vessels with sufficient accuracy.

While the method proposed for indicating speed might be desirable on board of men-of-war or large passenger steamers, it does not seem to me practicable for the great majority of freight steamers. Such vessels could not be expected to have electrical experts on board; but it seems to me it might be

well to make another distinction between the high-speed steamer and the steamer of ordinary speed. All steamers making less than ten knots might carry the present masthead and side lights, all over ten knots the range lights proposed by the essayist; thus we should have three classes of vessels, the high-speed steamer, the low-speed steamer, and the sailing vessel, marked by three distinct systems of lights. On sighting a vessel's lights at night, you would be able to tell immediately whether it be a sailing vessel, a low or high-speed steamer; if the latter, the system of range lights proposed by the essayist will enable you to tell with great accuracy the course and bearing. In the other cases such close accuracy is rarely necessary. In the case of the large high-speed steamers I think the possible error from steady heel need not be considered.

Fig. 1.


2 White Lts inclined 4 Pts to right of vertical
2 White Lts in a vertical line
2 White Lts inclined 1 Pt to left of vertical
2 Pts
3 Pts
4 Pts
4½ Pts
4½
4
3½
2½
1½
3 white lights
3 white lights
1 White stern light

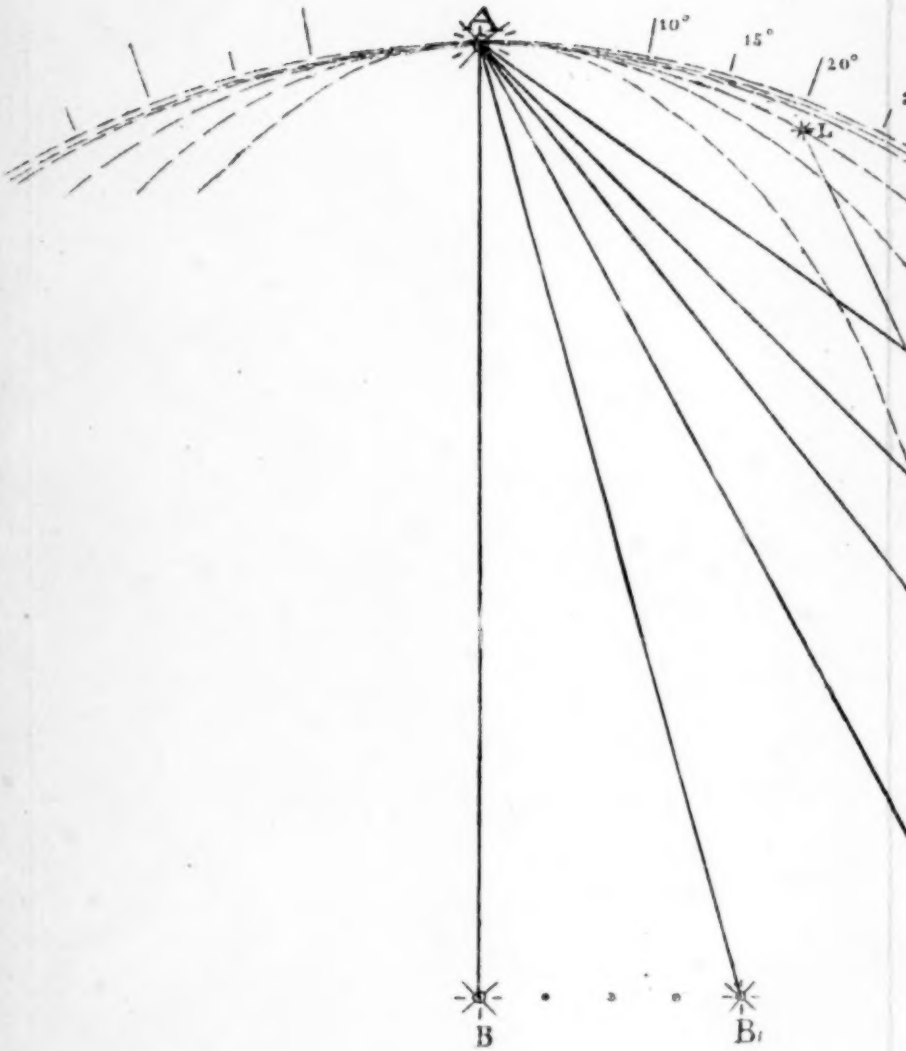
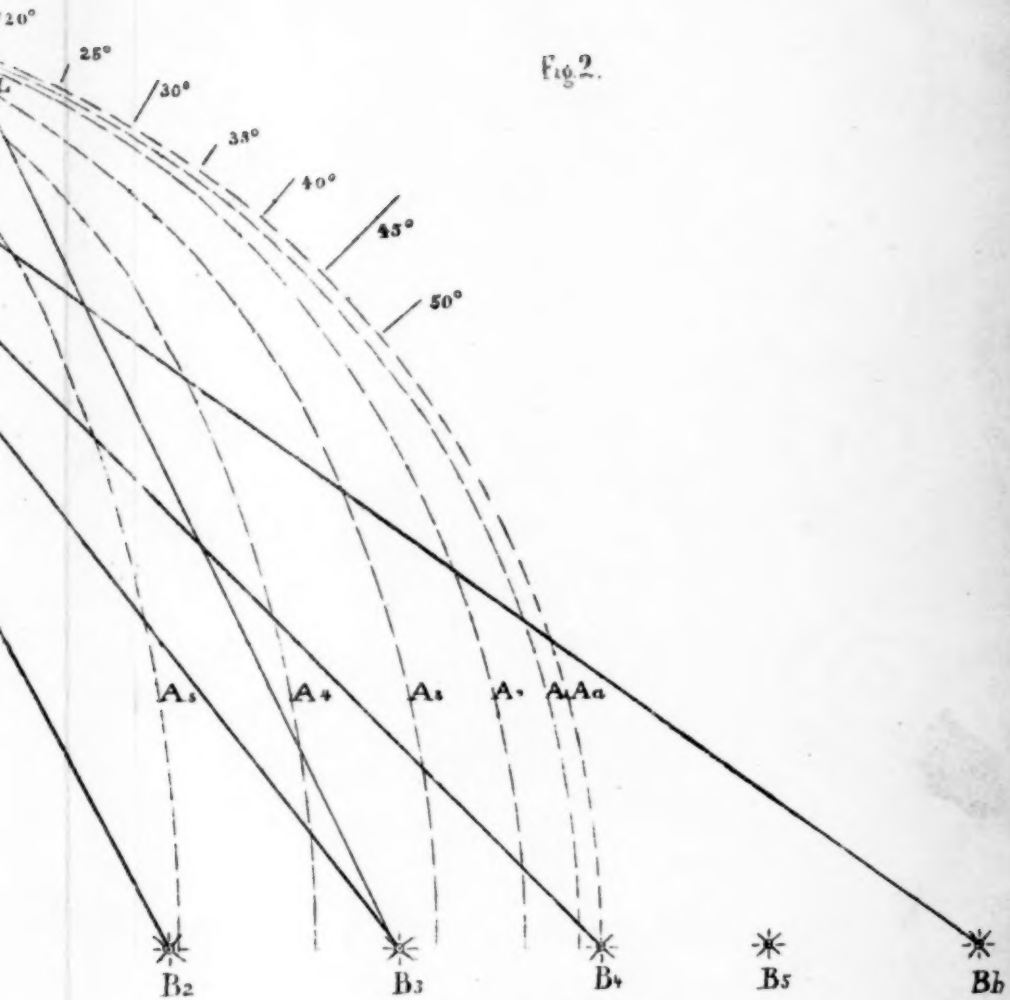

A
10°
15°
20°
B
B1

Fig 2.



U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

A PROPOSED METHOD OF RANGING GUNS, APPLICABLE TO FLAT TRAJECTORIES.

By Naval Cadet F. W. Jenkins, U. S. N.

The angle of elevation at which a gun must be set to obtain a given range is ordinarily obtained by laying the gun at different elevations, observing the ranges and interpolating for intermediate ranges. Several shots must be fired at each degree of elevation in order to obtain a good mean range, slight variations in the conditions of fire being sufficient to make an appreciable difference in the results, so that a single shot is not to be depended upon.

The increasing cost of ammunition makes it an object to reduce the number of experimental firings as far as is consistent with accuracy. Several methods have been proposed and used in calculating trajectories, but the theoretical and experimental results do not agree as closely as can be desired. The principal reason for this discrepancy has been that the resistance of the air depends largely on the form of the head of the projectile, so that some correction must be applied to tables compiled from experimental firings to make them applicable in case a different projectile than that for which the tables are computed is used. In using Mr. Bashforth's tables this correction is made by multiplying $\frac{d^2}{w}$ by a factor, A, depending on the form of the head of the projectile, d being the diameter in inches and w the weight in pounds. The theoretical value of this constant factor A does not, however, give good results in all cases. In order to avoid this difficulty and at the same time to decrease the work required in computing trajectories in the ordinary way, the following method is suggested:

The connection between range and angle of elevation in a non-resisting medium is given by the expression

$$\sin 2a = \frac{gX}{v^2}, \qquad (1)$$

in which X is the range in feet, g the force of gravity, v the initial velocity, and a the angle of departure (*i. e.*, the angle of elevation plus the jump, if there is jump). In a *resisting medium*, v_1, the initial velocity if substituted in this equation would give too small a value of a, and v_2, the final velocity at the range X, would give too large a value; evidently there must be some value, v_m, between the limits v_1 and v_2 which will give the correct value of a. In a resisting medium we might expect good results from a substitution of the mean value of the square of the velocity throughout the trajectory for v in Formula 1. For flat trajectories this mean value will be

$$v_m^2 = \frac{\int_{x_1}^{x_2} v^2\, dx}{x_2 - x_1}. \qquad (2)$$

An examination of Mr. Bashforth's tables of the resistance of the air shows that for high and low velocities the resistance is proportional to the square of the velocity; for velocities between 750 and 1350 f. s., however, the resistance is proportional to higher powers of the velocity, the cubic law of resistance being nearer the truth between these limits than the square. Now, if we call f the resistance of the air in pounds, and R the retardation or loss of velocity per second, we have

$$R = \frac{d^2}{w} f = -\frac{vdv}{dx}.$$

If the resistance of the air is proportional to the square of the velocity,

$$R = -\frac{vdv}{dx} = kv^2$$

$$\therefore \frac{dv}{v} = -kdx,$$

$$\log_e v = -kx,$$

$$e^{-kx} = v.$$

Substituting in (2)

$$v_m^2 = \frac{\int_{x_1}^{x_2} v^2 dx}{x_2 - x_1} = \frac{\frac{1}{k}\int_{v_2}^{v_1} vdv}{\frac{1}{k}(\log_e v_1 - \log_e v_2)},$$

$$\therefore v_m^2 = \frac{1}{2} \cdot \frac{v_1^2 - v_2^2}{\log_e v_1 - \log_e v_2}. \qquad (3)$$

Assuming that the cubic law is true, we have, by similar process,

$$R = -\frac{vdv}{dx} = kv^3,$$

$$\frac{dv}{v^3} = -kdx \quad \therefore \quad \frac{1}{v} = kx,$$

$$v_m^2 = \frac{\int_{x_1}^{x_2} v^2 dx}{x_2 - x_1} = \frac{\frac{1}{k}\int_{v_2}^{v_1} dv}{\frac{1}{kv_2} - \frac{1}{kv_1}} = \frac{v_1 - v_2}{\frac{1}{v_2} - \frac{1}{v_1}} = v_1 v_2. \tag{4}$$

Substituting these values of v_m^2 in (1), we have

$$\sin 2\alpha = 2gX \frac{\log_e v_1 - \log_e v_2}{v_1^3 - v_2^3} = \frac{2gX}{0.4343} \cdot \frac{\log_{10} v_1 - \log_{10} v_2}{v_1^3 - v_2^3}, \tag{5}$$

when $R \propto v^3$, and

$$\sin 2\alpha = \frac{gX}{v_1 v_2}, \tag{6}$$

when $R \propto v^3$.

In applying these formulas, Equations 5 or 6 are solved for v_2, the final velocity. Having given by experimental firing the initial velocity, and the range for a single angle of departure, one set of firings at a single angle of elevation should suffice for modern heavy guns up to 4000 or 5000 yards range, as will be shown in the examples quoted. Then, by the use of Bashforth's tables, with the values v_1 and v_2 from the formula as arguments, $A\frac{d^2}{w}X$ is found, and thence the constant $A\frac{d^2}{w}$, to be used in the calculations for other ranges. It must be remembered that the errors due to mathematical assumptions not strictly true, to inaccuracy of tables, to assuming that the distance travelled in the trajectory is equal to the range, etc., are all absorbed into the value A. When the angle of departure exceeds five or six degrees, the angles obtained by using a constant determined at a low elevation cannot be relied upon, owing to the greater curvature of the trajectory; but the error may be reduced by firing at a higher angle and getting a new constant.

The following examples will serve to show how the formulas are to be used:

From the Proceedings of the R. A. Institution, Woolwich, May, 1886, p. 356, we take the following data from the range table of the 12-inch B. L. gun, which is based on experimental practice:

$d=12''$, $w=714$ lbs. *M. V.* $=v_1$ in the formula, 1892 f. s. jump $+6'$, angle of elevation 3°. Range 3300 yards, using Formula 6.

$$\text{Sin } 2a=\frac{gX}{v_1v_2}, \text{ in which}$$

$X=9900$ ft.
$2a=6°\ 12'$
$v_1=1892$ f. s.
$g=32.2$

} and using these values, we find $v_2=1560$ f. s.

$$\therefore \frac{d^2}{w}AX=S_{1892}-S_{1560}$$
$$=1370.5,$$
$$\text{but } X=9900$$
$$\therefore \frac{d^2}{w}A=\frac{1370.5}{9900},$$

from which we find $A=.6864$.

It is, however, more convenient to use the log of $\frac{d^2}{w}A$ in the computation of other angles for assumed ranges, and in this case $\log \frac{d^2}{w}A=9.14124-10$.

We now wish to know the angle of elevation for 1600 yards.

We have $\frac{d^2}{w}A\ 4800=S_{1892}-S_{v_2}$, and from this formula we find $v_2=1725$ f. s. By Formula 6 we have

$$\sin 2a=\frac{32.2\times 4800}{1892\times 1725},$$

or
$$2a=2°\ 43'.$$

Subtract twice the jump, since a is the angle of departure, and we have

$$2 \text{ elevation}=2°\ 31',$$

or the angle of elevation for 1600 yards $=1°\ 15'\ 30''$. The range table constructed from experimental firing gives $1°\ 16'$ as the angle of elevation for 1600 yards.

Again, to find the angle of elevation for 4000 yards, we have

$$\frac{d^2}{w}A\ 12{,}000=S_{1892}-S_{v_2}$$
$$\therefore v_2=1495.2.$$
$$\text{Sin } 2a=\frac{32.2\times 12{,}000}{1892\times 1725},$$

or
$$2a=7°\ 51'.$$

Subtract twice the jump, we have 2 elevation $= 7° 39'$, or the angle of elevation for 4000 yards $= 3° 49' 30''$. The range table gives $3° 50'$ as the angle of elevation for 4000 yards.

The following tables show the results as obtained by the formulas as compared to those obtained by experiment, and in the case of the 8-inch M. L. R. to results obtained by Bashforth's method.

6-inch steel B. L. R. jump $+ 10'$. *M. V.* 1915 f. s., $d = 6''$, $w = 100$ pounds. Radius of head of projectile, 2 calibres. Experimental results quoted are given in Proceedings Naval Institute No. 37.

1st Case.—Assuming that $R \propto v^3$:

	Elevation.		
Range in Yards.	Experimental.	By Formula.	Difference.
3714	4°	3° 53′	−7′
4375	5	4 56	−4
*4990	6	6 00	
5550	7	7 03	+3
6057	8	8 04	+4

Value of A in this case 0.63767.

2d Case.—Same gun, same data. Assuming that $R \propto v^2$:

	Elevation.		
Range in Yards.	Experimental.	By Formula.	Difference.
3714	4°	3° 56′	−4′
4375	5	4 58	−2
*4990	6	6 00	0
5550	7	7 00	0
6057	8	7 58	−2

Value of A in this case 0.70685.

The range marked thus * was used with the corresponding angle of elevation to determine $\frac{d^2}{w} A$.

The 8-inch M. L. R. (converted). *M. V.* $= 1450$, $d = 8$, $w = 180$ pounds.

Assuming $R \propto v^3$:

Range in Yards.	Elevation. Bashforth.	By Formula.	Difference.
200	0° 16′	0° 16′	0′
400	0 32	0 33	+1
600	0 50	0 51	+1
800	1 08	1 09	+1
1000	1 28	1 28	0
1200	1 48	1 48	0
1400	2 09	2 09	0
1600	2 31	2 30	−1
1800	2 53	2 53	0
2000	3 16	3 14	−2
2200	3 40	3 37	−3
*2365	4 00	4 00	0
2600	4 30	4 30	0
2800	4 58	4 56	−2
3000	5 26	5 23	−3

Value of A in this case 0.71198.

12-inch B. L. R. (English), column marked *experimental*, taken from Proc. R. A. Inst. May, 1886, p. 356, and based on practice of 24th and 25th February, 1885, 17th April, 1885, and 23d June, 1885. $W = 714$ pounds, jump $+6'$, $M.\ V. = 1892$ f. s. Form of head not given. Assuming $R \propto v^3$:

Range in Yards.	Elevation. Experimental.	By Formula 6.	Difference.
200	0° 04′	0° 03′	−1
400	0 13	0 13	0
600	0 23	0 23	0
800	0 33	0 33	0
1000	0 44	0 43	−1
1200	0 54	0 54	0
1400	1 05	1 04	−1
1600	1 16	1 15	−1
1800	1 27	1 27	0
2000	1 38	1 38	0
2200	1 50	1 50	0
2400	2 02	2 02	0
2600	2 15	2 14	−1
2800	2 28	2 27	−1
3000	2 40	2 38	−2
*3300	3 00	3 00	0
3400	3 07	3 06	−1
3600	3 21	3 21	0
3800	3 36	3 35	−1
4000	3 50	3 49	−1

Value of A in this case 0.6864.

* Used to determine constant.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES ON ELECTRICAL TESTING AND MEASURING APPARATUS FOR SHIPS.

By Ensign S. Dana Greene, U. S. N.

The introduction into a modern man-of-war of elaborate electrical plant has brought into prominence the necessity of having some kind of apparatus on board ship for testing the condition and efficiency of the plant from time to time. When it is remembered that a "plant" now-a-days includes circuits for search lights, incandescent lamps, for guns, torpedoes, gongs, bells, etc., the necessity for having some instrument wherewith to test these various circuits, or to localize faults in them, becomes apparent.

The leading of the wires on board a vessel is, of itself, a laborious undertaking, for so many precautions have to be observed. Thus, wires must be out of the way of an enemy's shot and shell as much as possible, they must be accessible, must be protected from chafe, salt water or undue strains, and the various circuits must be conveniently located for those who are to use them. As a rule, wires are led below the water line wherever possible, double circuits being used above the water line, and whatever apparatus is put on board ship should also be below the water line if possible.

The most ready means of testing circuits, determining whether or not they are in good condition, whether there are breaks, short circuits, etc., is to measure the *resistance* of the circuits, or test their continuity by means of a galvanometer and battery. To enable officers in charge of electrical plant aboard ship to make these tests, there has been devised at the Torpedo Station an apparatus which seems to fulfill the requirements of compactness, simplicity and completeness, and which is called the "Electrical Testing-Table." It

consists of a stout wooden locker containing the voltaic batteries sent to the ship, to the top of which is secured a rectangular table with all the testing apparatus permanently secured to it. To protect the table from dampness, careless handling, etc., it has a cover fitting over it provided with a lock and key. On the table are secured:

1. A *plug switchboard* having binding screws for the attachment of permanent wires to gun and torpedo circuits, a return wire, an earth circuit, and the wires from the batteries in the locker. The switchboard is also permanently connected to wires leading to the measuring apparatus (on another part of the table), and by the insertion of plugs at the proper points in the switchboard any circuit may be connected with the measuring apparatus.

2. A *plug commutator* for connecting the poles of the measuring battery to the measuring apparatus, which is called a *rheometer*.

3. An arrangement for testing the condition of the batteries at any time.

4. The *measuring apparatus* or *rheometer*, with a galvanometer for use with it.

The battery-testing arrangement consists of a resistance coil, an ordinary service fuse bridge, and a contact key, let into slots cut in the top of the table, connected together by wires, in series, and also to the plug switchboard. By manipulating the plugs of the latter, any battery in the locker below can be thrown into circuit with the testing arrangement, and on pressing the contact key (and thus closing the circuit) the fuse bridge should be heated to a bright red color if the battery is in good condition. The fuse bridge is protected from being broken by a piece of glass fitting over the top of the slot.

The rheometer (a plan of which is shown in Fig. 3) is constructed on the principle of the *Wheatstone bridge*, which is as follows:

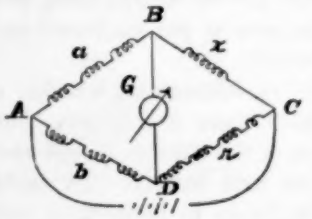


FIG. 1.

Suppose we have a network of conductors, $ABCD$, arranged as in Fig. 1, the arms AB, AD, DC having known adjustable resistances a, b and r in them, and the arm BC a resistance x to be determined. If the resistances a, b and r are so adjusted that there is no deflection shown on the galvanometer G, the points B and D must be at the same *potential* or *pressure*; otherwise there would be a current in the galvanometer circuit, and hence a deflection

on the galvanometer. When the above condition is fulfilled the following relation holds between the resistances in the arms:

$$\frac{a}{b}=\frac{x}{r} \text{ or } x=\frac{a}{b}r.$$

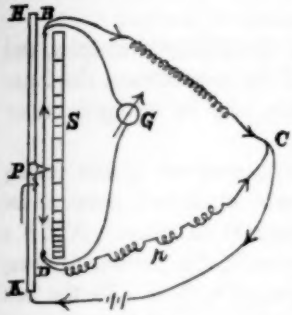


FIG. 2.

Now, suppose that instead of having adjustable resistances in the arms *AB* and *AD* (Fig. 1), we have an arrangement like Fig. 2, in which *BD* is a uniform wire of a certain known length *l*, *HK* is a metal bar, having a metal pointer *P* sliding on it, the latter making a sliding contact with the wire *BD*. The current now enters by the bar *HK*, passes to the wire *BD* by means of the pointer *P*, and there splits, part going one way and part the other, as shown by the arrows. If now the pointer *P* is moved along the bar *HK* until there is no deflection shown by the galvanometer, and if we call the resistance of the wire *BD* to the *left* of the pointer, *a*, and that to the right of the pointer, *b*, we shall have, as we did in Fig. 1,

$$\frac{a}{b}=\frac{x}{r} \text{ or } x=\frac{a}{b}r.$$

Now, suppose that instead of taking the *actual resistance* of the wire *BD* on each side of *P*, we call *y* the resistance per *unit of length* of the wire, and that when the balance is obtained, *P* is distant *v* inches from *B*. Then *P* is distant $l-v$ inches from *D*.

Suppose also that $x=nr$. Then

$$\frac{a}{b}=\frac{vy}{(l-v)y}=\frac{x}{r}=\frac{nr}{r}=n \text{ or } \frac{v}{l-v}=n; \text{ hence } v=\frac{n}{n+1}l.$$

To find *v* for different values of *n*:

If $x=0.1\,r$, then $v=\frac{.1}{1.1}l=\frac{1}{11}l$

" $x=0.2\,r$, " $v=\frac{2}{12}l=\frac{1}{6}l$

" $x=0.3\,r$, " $v=\frac{3}{13}l$

" $x=0.5\,r$, " $v=\frac{5}{15}l=\frac{1}{3}l$

" $x=0.9\,r$, " $v=\frac{9}{19}l$

" $x=1.0\,r$, " $v=\frac{1}{2}l$

" $x=2.0\,r$, " $v=\frac{2}{3}l$

" $x=3.0\,r$, " $v=\frac{3}{4}l$

etc., etc., etc.

These values of v can be marked on a scale the ends of which are opposite the ends of the wire BD (Fig. 2), and then when a balance is obtained it is only necessary to observe the reading of the scale S as indicated by the pointer P, multiply it by r, the known resistance, and we have the value of the unknown resistance at once.

The rheometer is constructed on the foregoing principles, and Fig. 3 gives a plan of the rheometer and its connections, the latter being led under the table wherever possible, and let into grooves on the under side of the table.

$QSTV$ is the base board, of hard wood, secured to the testing table. G_1G_2 is a uniform platinum-silver wire stretched between the binding posts G_1 and G_2 and soldered securely to them. NN is a brass bar having the pointer P running upon it, the pointer pressing on the wire G_1G_2 and making metallic contact with it. In the box W are four resistance coils of 1, 10, 100, 1000 ohms resistance respectively, the ends of the coils being connected to adjacent pieces of the switchplug B, as shown. By this arrangement any one, or more than one, of the coils can be thrown into the circuit of the adjustable arm when desired. RM is the scale, graduated as before described, the extremities of the graduation being abreast the ends of the wire G_1G_2. W' is a metal switch pivoted at the binding post b, and which can be switched on to either of the brass stops marked *Tel.* and *Gal.* I is an induction coil; one end of the primary coil is connected to the stop marked *Tel.*, and the other end, through the interrupter J, to the binding post d.

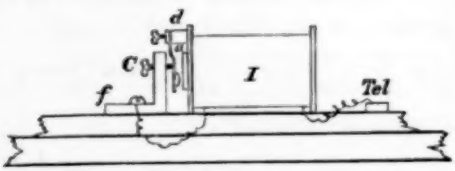


FIG. 4.

This interrupter (see Fig. 4) consists of a brass spring a with a soft iron armature at its extremity, the spring being permanently attached to the binding post d. One wire from the battery goes to this binding post. The spring presses ordinarily against the screw c, which works in the frame f. When a current passes through the primary coil, the coil, acting as an electro-magnet, attracts the soft

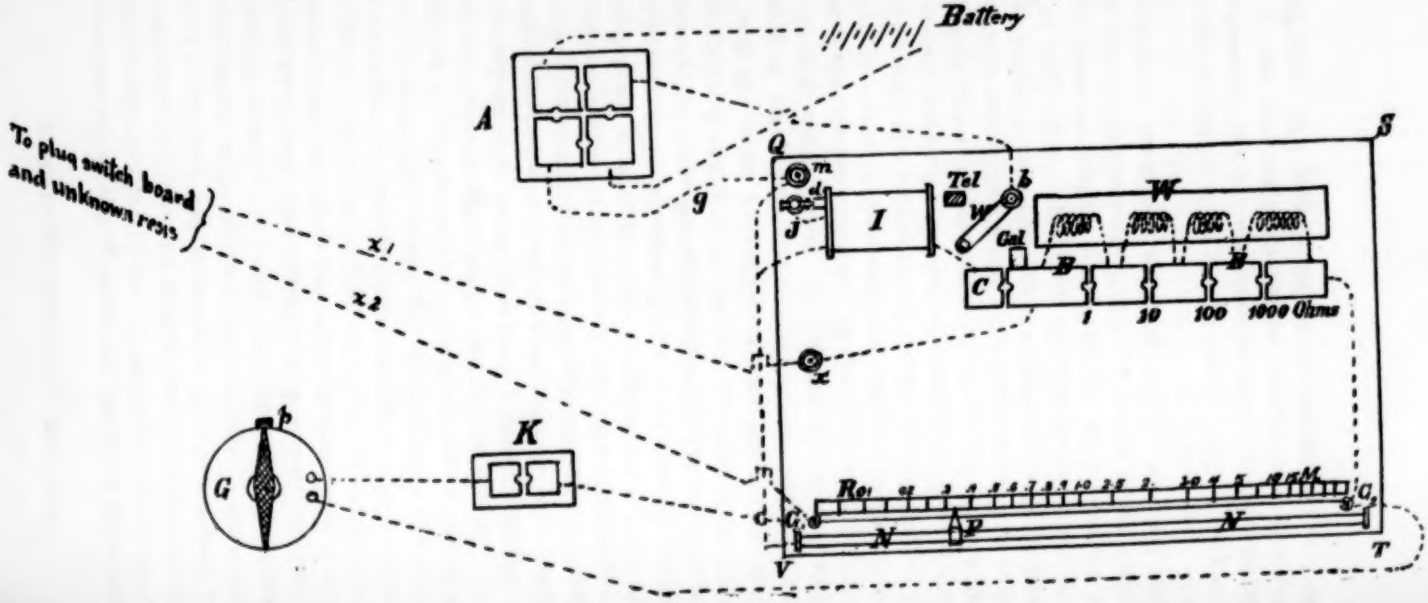

Battery
A
To plug switch board and unknown resis
x1
x2
Q
S
m
d
J
I
Tel
W
b
Gal
W
C
E
E
1
10
100
1000 Ohms
x
K
G
p
Ro
N
N
V
T

FIG. 3.

iron armature of the spring and draws the latter out of contact with *c*. This breaks the circuit; the coil no longer acts on the iron armature, and the spring flies back against *c*, thus establishing the circuit again. This making and breaking of the circuit results in a rapid, vibratory motion of the spring *a*, the amplitude of the vibration being regulated by working the screw *c* in or out. This vibratory motion is utilized when using the telephone, as described later on.

One end of the secondary coil of the induction coil *I* is connected to the piece *C* of the switchplug *B* (Fig. 3), and the other end, to the wire between the binding post *m* and the rod *NN*. *K* is a switchplug in the circuit of the astatic galvanometer *G*. The latter has two coils, one of 10 and one of 100 ohms resistance, either of which can be used; the galvanometer needle is kept parallel with the plane of the coils ordinarily by means of a small permanent magnet *p*, placed vertically opposite the zero of the galvanometer scale. *A* is a plug commutator connected to the measuring battery and to the rheometer by permanent wires. All the connections of the rheometer are shown by dotted lines in Fig. 3. The commutator is used when it is desired to reverse the direction of the current through the rheometer.

Ordinarily, the apparatus would be used as follows: The pins in the plug switchboard having been arranged so as to connect the proper circuit with the wires x_1, x_2 (Fig. 3), see the pin out at *C* in the switchplug *B*, and put the pin in at *K*, also throwing the switch *W* on to the stop marked *Gal.*; unplug one of the resistances in *W* (the one that corresponds nearest to the known approximate resistance of the circuit to be measured) and slide the pointer *P* along the wire G_1G_2 until the galvanometer shows no deflection. Then the scale reading shown by the pointer, multiplied by the unplugged resistance *W*, gives the resistance of the circuit or wire measured, *plus* the resistance of the "leads"; the resistance of the latter, being measured before or afterwards, can be deducted from the total resistance. In plugging or unplugging, the pins should never be pushed or pulled sideways; a slight turn of the pin will always seat it well in place, or start it from its seat. If this precaution is not observed, the pinholes become warped or enlarged, and the pins will make bad contact.

Although the needle of the galvanometer is held steady ordinarily by its permanent magnet, there may be occasions when, owing to the motion of the vessel or other causes, the galvanometer cannot be depended upon. To provide for such a contingency, a small tele-

phone, with wires attached, is furnished with the testing table, to be used in connection with the induction coil *I*. To use it, the following changes in the connections must be made: Take out the pin at *K* and put it in at *C*; change the battery wire *g* from the binding post *m* to the binding post *d*, and throw the switch *W'* on to stop marked *Tel.*; unplug one of the resistances *W* as before. Now connect the ends of the telephone wires to the binding posts G_1 and G_2 and put the telephone to the ear. The vibrations of the interrupter spring, when they are properly regulated by the adjusting screw, make themselves known in the telephone by a peculiar humming or buzzing sound. Move the slider *P* along the wire G_1G_2 until the humming ceases, when the balance is obtained. The unplugged resistance, multiplied by the scale reading, as before, will give the *approximate* resistance of the circuit or wire measured. It will usually be found that there are two positions of the pointer *P* in which the humming ceases, depending upon whether the pointer is moved *up* or *down* the wire. The mean of the two scale readings so obtained may be taken as the true reading. For use with the rheometer a battery of four sawdust or other similar cells will be supplied. The current from this battery, however, will not operate the interrupter of the induction coil, and hence when the telephone is used, the firing battery, in the same locker as the other, can be employed. When so used, the circuit should be kept closed as short a time as possible, as the firing battery will soon run down if left on a closed circuit for any length of time. The firing battery should never be used with the galvanometer, as the current is strong enough to fire a fuse, if one should happen to be in the circuit that is being measured or tested; hence it is well to get used to the testing battery whenever the galvanometer is used. With the telephone, only the secondary current goes through the circuit to be measured, and as this is so small, there is no danger of a fuse being fired; hence the firing battery can be safely used to furnish the *primary* current in this case.

While the rheometer is not so accurate or sensitive as the ordinary form of Wheatstone bridge unless the measured resistance approximates quite closely to one of the known resistances, 1, 10, 100, 1000 ohms, it is better adapted for use aboard ship for the following reasons:

1. There are many fewer resistance coils, whose connections are liable to be broken or the coils themselves injured by burning, short-circuiting, or otherwise; hence it is more compact and cheaper.

2. There are not so many pinholes to get out of shape by careless plugging or unplugging.

3. It can stand much rougher handling, and hence is not so liable to be injured by the motion of the vessel, shocks due to firing of guns, etc. This last condition, however, must not convey the idea that the rheometer should be handled or used with any less care then a bridge should be. Any instrument of the kind should be handled intelligently and carefully.

Besides the testing table described above, vessels are now supplied with a small "testing dynamo," weighing only four or five pounds, and very handy, having a bell or gong in its circuit. This bell will ring with a resistance of 5000 ohms in the circuit. In the torpedo-supply box will also be found a "pocket galvanometer," about three inches in diameter only, and which is a combination of a small battery and a galvanometer. It can be used either as a *battery and galvanometer* combined or as a *galvanometer* alone. The testing dynamo and the pocket galvanometer are very useful for testing the continuity of a circuit quickly, testing a fuse or detonator, localizing a break in a circuit, and for many similar purposes. Besides the various instruments already described, officers in charge of the electrical outfit aboard ship will find many articles therein which will serve as material for improvised instruments, either to aid the officer in his routine work or in any special work required, and which will readily suggest themselves to his mind when needed.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

OCTOBER 13, 1886.

COMMANDER W. T. SAMPSON, U. S. N., in the Chair.

NAVAL REORGANIZATION.

BY CAPTAIN A. P. COOKE, U. S. N.

Ideas are in the air, as Emerson says, and they belong no more to one individual than another. It is impossible to sequestrate an idea for one's exclusive use. The subject of naval reorganization seems now to be in the air, and to occupy naval thought.

The present able head of the Navy Department perceived at once the want of proper organization, and has suggested important changes to meet this great need. The Secretary of the Navy is always a statesman of ability, selected from the people for the control of a great department, but he is not expected to be familiar with the details of naval management, and must rely upon those officers of repute and experience whom he gathers about him as his advisers and as members of his official family. The first necessity is to have this body properly organized, so they may all work together for good and the various branches of the service be efficiently supervised, while, at the same time, the chief control and responsibility may be gathered into one comprehensive head, where it belongs.

The Constitution of the United States declares the President shall be commander-in-chief of the Navy. He is therefore at liberty to perform in person the functions of the Admiral-of-the-Fleet; or he may, at his discretion, appoint an executive commander-in-chief; but he cannot confer upon him his own supreme authority, although he may permit him to carry out his own plans. The question first presents itself as to what are the proper functions of the Secretary of the Navy as regards strictly naval matters and the management of the fleet. Can the President delegate to him the actual command of the Navy or any part of it? Or should he for this purpose assign

an officer of the Navy duly commissioned, or appoint a commission of officers for the purpose of executing the duties of the office of Admiral-of-the-Fleet? This latter course would seem to be the best available.

The commission thus appointed to execute the duties of the office of Admiral-of-the-Fleet would, by their experience, technical education, and general training, be eminently qualified to look after the many details of the service which must be unfamiliar to any one not educated in it.

The unit of organization in the Navy may be considered the single ship, and here the distribution of authority and responsibility is complete; the captain is supreme, and is ably and thoroughly assisted by his staff, with the executive at its head. The chiefs of the various departments look after their respective branches, but running through all is the responsibility of the executive and his assistants, the direct aids of the commander. Next comes a combination of single ships, forming a squadron, under the command of a flag-officer. Here, too, the responsibility and distribution of authority are complete. The captains are held responsible for the units of the formation, and the commander-in-chief looks to them for the efficiency of the single ships. As the executive and the officers of the deck are the immediate aids of the captain in carrying on the affairs of the single ship, so the admiral's staff and the captains of the single ships are immediately responsible to the commander-in-chief for the efficiency and management of the squadron.

Now we have gotten to the end of efficient organization in the American Navy. When we come to the management of squadrons and looking after the general interests of the whole fleet—its outfit ashore, and its efficiency afloat—the weakness of our system is glaringly apparent. We have no proper organization for carrying on efficiently the office of Admiral-of-the-Fleet. This office is located in the Navy Department. Here there are many bureaus, which carefully and faithfully guard the interests of the various branches of the service, but there is no office which effectually looks after the Navy as a whole. What we want is a commission to assist the Secretary of the Navy, and relieve the political head of the department of the many technical details for which he has neither the time nor the aptitude, and which cannot be safely delegated either to clerks or to chiefs of bureaus, who have as much as they can do to attend to their own offices.

Time would fail me to recount the many instances of conflicting authority and cross-purposes which have occurred in the dealings of the various branches of the department with the affairs of the Navy, both ashore and afloat. But they are well known to the members of the Institute, and cause us all to appreciate the radical defects in our organization.

The occupants of the Office of Naval Intelligence should constitute the staff of the commission appointed to execute the office of the Admiral-of-the-Fleet, and would represent an establishment corresponding to the general staff of an army, which is now an essential part of all modern military organizations. This arrangement only gathers up the threads of much that is now left at loose ends, and for which no one is responsible, and cannot in any way interfere with the legitimate field of the technical bureaus. These will continue to be responsible for the fullness of the information and the correctness of the work in their own particular branches, but the management of the Navy will be placed where it belongs, in the Secretary's office; and all orders will be issued from headquarters, and each bureau will no longer have authority to issue general instructions "By order of the Secretary of the Navy," but will attend to its own line of business and confine itself to its own affairs.

In time of war, the department must be suddenly charged with the organization and superintendence of new and arduous naval operations on a large scale, in addition to its current business, and could not, possibly, as now arranged, devote itself to the numerous details, or give the time and attention needful fully to protect the interests of the Government.

The problems of reorganization and reform are too large and intricate to be solved by any individual expression of opinion, but we can all add our mite, and let us hope the fittest ideas may survive and take shape, and be crystallized into some practical form for our mutual benefit. Nor should we be deterred because we appreciate our inability to say much. We can at least construct a thread on which wiser men may hang their beads of wisdom. It may be said the present organization has worked successfully in the past. In the old days, before steam and telegraph, when sails and smooth-bores were our only resource, our organization was sufficient and ample for the times. During our late war, in which we had no prepared naval antagonist to encounter, the duties of Admiral-of-the-Fleet were very ably performed by Captain Fox, a brilliant and talented officer of

great and varied experience, and he felt very much the need of an Intelligence Office, and the store of ready information only there to be found.

Here comes the great advantage of the General Staff, which, I fear, has not been fully appreciated; and we can all remember what opposition the Intelligence Office had to contend with when it was first organized. And now, for a moment's digression, let us reflect how difficult it is to make any changes.

It is astonishing how stubbornly any innovation is resisted, and how blindly we go on failing to observe the signs of the times. When a theory in regard to any important subject has become imbedded in the thought of the time, and when it shapes some important department of public action, so that any change involves the pride of opinion, and would affect varied interests, such a thing will often long maintain its authority after it has been proved false both by reasoning and by experience. The old rulers of thought and practice distrust, or perhaps scorn and ridicule, the new men and their speculations; and Truth, however plain, cannot for a time get herself recognized, and the established opinions and all the related interests struggle hard to maintain their position, and fact and reason are often alike discarded. As a class, we are committed to things as they are, and follow the footsteps of illustrious predecessors, the gallant leaders who have gone before and won renown and honor with the very tools and means which the new men would so ruthlessly sweep away. Prejudice and interest interpose to prevent rational conclusions being consummated.

But to return to the General Staff. Its importance cannot be overestimated, and its services should be utilized to the fullest extent. Its chief labors would be directed to one important end—the preparation for war—so that when the time arrived there might not be a moment's delay. In war the General Staff would be the mainstay and reliance of the department and of the admirals afloat. It would keep itself in close and intimate relations with the outer world, to catch the first intimations of the enemy's movements and to inform the fleet of all his doings and intentions. Members of the General Staff would go with the fleet, and the store of accumulated information in their possession would be kept posted up to the last moment. Previous knowledge and preparation are so essential to success in war, that without a perfected and thoroughly worked-out system of this nature the best ships and equipment will be unavailing. If the

information required is not ready in a concentrated form when war breaks out, it cannot be suddenly obtained, and our operations must be behindhand, and our fleet at a disadvantage continually. The General Staff must necessarily be equipped with the most zealous and efficient officers, and aided by all the available talent of the Navy.

And now let us look again for a moment at the single ship. Her carrying capacity is limited, as well as her resources, and every object, both animate and inanimate, occupying her valuable space should be able to perform as great and varied service as possible. Emergencies acquaint one with strange requirements, and when half the resources at command, and upon which one is accustomed to rely, are suddenly swept away, one must gather up the fragments which remain and make the most of what is left. The quality of these will depend upon the original capacity of the whole. We are aware that at the present day the tendency is to indulge greatly in specialties, and much benefit comes from this division of labor. But on shipboard, where space is limited and all should know how to fight and manage the ship, this tendency must be kept within reasonable bounds by other greater considerations. For instance, the medical profession is divided into many specialties, and some of those would be exceedingly useful on board ship, but, owing to the limited space afforded for quarters, we are obliged to content ourselves with one set of medical officers, who have to combine in themselves all the expertness which can be afforded. So, too, in the matter of torpedoes, electricity, gunnery, and navigation. There is enough in each of these branches to occupy the special attention of different corps, but in the organization of the *personnel* of a man-of-war for effective service it is impossible to have men who devote themselves entirely to these specialties and are fit for nothing else. Suppose, at the beginning of an engagement, half of them should be killed—which is quite likely to be the case—or suppose, during the cruise of a ship, many valuable prizes should be taken, and it became necessary to dispatch these in charge of prize crews: the necessity of having officers of varied accomplishments is apparent. Only a few officers, at best, can be supplied a ship, and it requires very little appreciation of the necessities to realize they should all, as far as possible, be able to take each other's place, and share the responsibilities of fighting and managing the vessel.

The modern fighting ship is dependent upon engines, as the old-fashioned man-of-war was upon sails, and the officers of the latter

with their subordinates were able to care for their vessels in all the exigencies of service, although themselves not expert shipwrights or riggers or sailmakers. So, in the present day, officers of the modern fighting ship must be able to care for all her belongings without the aid of a special class of officers who do nothing but look after the engines and are available for no other service.

In the education of our naval cadets they are taught the same branches, irrespective of the special duties to which their corps selection may call them. And on shipboard, when the vessel is under steam, they have charge of the engines, and when the ship is under sail they are given charge of the deck. They are also exercised in the other important duties of their profession, which fits them to fight and manage a ship and care for her people. This same arrangement of service should be continued when the young gentlemen are promoted to ensigns, and so on through the different grades of watch officers. Then it would be unnecessary to make any further appointments in the engineer corps, and the service would soon become more homogeneous and united. Ultimately an officer might be detailed as chief engineer, just as now he is selected for navigation, and he need not know how to design or build an engine any more than the navigator must know how to design and build his chronometer or compasses, or the officer of the deck must be able to design or build the sails or spars.

The office of the designers and builders is finished when the completed article comes into our hands, and that of the directors and managers begins. A corps of skilled and organized experts must now take charge of the complicated machine. We are told "a man-of-war's-man of to-day is not a mere seaman, but a trained warrior. He is an accomplished artillerist, a skilled rifleman, a trained swordsman, a practical electrician, an experienced machinist, and a superior torpedoist rolled into one." This long list of accomplishments necessary for a modern man-of-war's-man shows how impossible it is to indulge in specialists on board ship.

The engine department of our modern ships will require a large portion of the crew, and this large detail must surely be taught something besides the management of engines. Our engineer officers are required to do nothing now but care for these appendages. In the old times it was found impracticable to have sailors to care for the ship only, and soldiers to do the fighting, so now the sailor-soldier must, as far as possible, be a jack capable of lending a hand at all the

trades represented in our ships; and the officers should be all equally versatile.

Lately the marine officer has been made a sailor by choosing him from the graduates of Annapolis; but it would be better to have him only temporarily detailed for that service. There is no good reason why the paymaster should not be available as a sailor or a soldier, according to the emergency of the moment, and this could be readily accomplished by selecting him from the body of trained naval officers.

In these days of rams and torpedoes, it may be expedient for a ship's company to take to her boats suddenly and unexpectedly, in which case it might be very embarrassing to have a large portion of the people perfectly helpless in the water and unfamiliar with the boats. Every officer should know how to manage and navigate a boat, and should be accustomed to the command of men, and the number of non-combatants should be reduced to a minimum.

As far as possible, every officer ought to serve in every department and branch of the Navy for a reasonable period of time, in order that he may be familiar with other duties than those specifically attached to his ordinary assignment. It is only in this way that he can gain the necessary experience and be sufficiently many-sided to be efficient in emergencies, or capable of performing those many valuable services which he may, in time of need, be required to render.

The introduction of apprentices into our service was a most important step for its improvement, but it has been somewhat halting and incomplete. To make it more effective a larger number should be employed, and the Navy manned as far as possible by those who have been regularly trained for its service, so that all our "bluejackets" might come from the same source, own the same training, love the same country, and glory in the same traditions. Unfortunately, we find a large proportion of these American boys fail to re-enlist, but I think that proportion can be reduced by judicious management on our part, and when our service is placed on a proper footing. Its defects are as apparent to the men as the officers. They go to sea with reluctance and serve without spirit and without interest, because they find there is nothing in it, and that they are dealing with superannuated and ineffective material which must be swept away and replaced before any good can be accomplished. They find that the service is neglected and unappreciated, and that their best efforts can avail nothing. We need a mighty stirring up.

We are becoming laggards in the race, and the lethargy of routine is settling down upon us. New ships, modern fittings, a new armament, effective equipment, and a better class of men, will do away with this and inject new life into our service.

What we want is a compact body of American seamen kept together by mutual ties and common joys; men of the same household and partners in the same glorious inheritance. It must be expected that a fair proportion of those educated at the training school will not remain in the service, and allowance must be made for this loss—though they are not entirely lost, for in time of war they would be leading recruits and probably the first to present themselves, and their previous training would increase their value immensely. And is not this provision for its defense the legitimate duty of the nation?

We hear of frequent propositions to spend millions in the education of voters, and a modest portion of the public revenue would be most profitably invested in the training of the country's defenders. Only a small portion of the naval officers educated at the public expense are received into the service. We could well afford to educate, in the same way, naval apprentices to be returned to the body of the people and find their occupation in civil pursuits. This would be a most profitable national investment, and in the hour of their country's need they would be the men to leaven the whole lump of patriotic naval volunteers, and be the expert nucleus of our sea contingent, our reliable reserve. And to make this more popular I would have apprentices enlisted from every section of our country. The officers come from all parts of the land, and so should the men; then we would have a purely American Navy, really representing our people. I would train the apprentice as long as I did the cadet, or until he was twenty-one, and then require him to serve a reasonable term of years in order that he might in some small measure compensate the Government for the great honor and distinction bestowed upon him in his selection and careful training for his country's service. None but Americans should be on our ships, whereas a large percentage of our crews are aliens and people of ambiguous nationality, some of them speaking with difficulty our language. Representatives of almost every flag that flies on the sea are to be found at our guns, and the ease with which foreigners may enter our service would make it a very simple matter, in time of war, for the enemy to have informers and spies in our ranks whose presence it would be difficult

to detect. Surely such men cannot be expected to give a good account of themselves in time of war. Nor is this the proper material to put on guard or waste time in training, where every man is expected to do his duty, unless we are to have a peace navy and a war navy, and even then there may be hardly time to gather the peace navy in from the four quarters of the globe under the comforting wings of the great American Eagle, while we set about building and equipping and manning a war navy.

As it will be a long time before we can rely on the training school to supply all our men, we must still have recourse to ordinary enlistments, and there is no reason why the naval service should not be made attractive as a career for young men of good habits and fair education. We have thousands of just such young men, carefully brought up with sufficient education, but devoid of prospects; the tone of the service needs raising, and there seems no reason why we should not introduce a higher order of recruits, and thus make the Navy more representative and popular. We must begin by placing it as much in harmony as possible with the other walks in life which the men we wish to attract may follow.

It may be laid down as a general principle that the greatest attraction will be found to be the shortest possible period of binding service, so that the recruit may feel his liberty has only been pawned, not sold, and that it rests with himself to redeem it almost at will. An employer would obtain but few men if he insisted on a binding agreement for a number of years, with severe penalties for leaving his service, while his men had practically no redress against discharge. Short service would give an opportunity for good men to try the Navy before they elected it as a career.

For the first service of recruits I would permit them to enlist for one year, if they were born in the United States and came up to a fair educational standard, but these men would have to engage for three years on their next enlistment. Some would re-enlist, and the number would be greater as the service improved. Those who failed to return would probably be the first to enlist in case of war, when it might be necessary to increase our force.

Men enter the Navy for various reasons, but chiefly to escape from want or to be free from care, with a future hopeful, if not assured. Many of the idle, the incompetent, and even the criminal, find their way into the service—the waifs and strays left stranded by the active tide of human labor. Out of such material are frequently made the

sailors who have the country's honor in their keeping. But they are not the best we might find in the country, and their character keeps out better men, who would join had they not to live with such associates. Because good men will not enlist, worse are taken, and because of the conduct of these, good men will not stay. This vicious circle spreads and forms other rings. On account of the character of some, the whole Navy must be managed by a system of discipline which would be unnecessary with better material. A remedy must be found if our Navy is to become national and representative of our best qualities. The enlistment of men whose habits or course of life have closed for them other avocations, and who seek the Navy as an asylum of last resort, should not be permitted.

The livery of the United States should be made a badge of character and worth, and the privilege of wearing it considered a great honor, so that young men of spirit and ambition, who are anxious to elevate themselves while serving their country, will be glad to enlist in the Navy. They should be enabled to realize and appreciate the fact that the discipline and instruction acquired during their term of service tend to fit them for the duties of positions of trust and responsibility in civil life when honorably discharged. And the general public would soon learn to recognize an honorable discharge as a certificate of courage, intelligence, subordination, steadfastness of character, and reliability in any pursuit. We should endeavor to elevate the enlisted man, to arouse his self-respect, and thereby enable him to command the respect, admiration and confidence of his fellow-citizens. We must endeavor to attract a higher order of recruits, and thus regenerate the ranks, extirpating all that is low and demoralizing while we instil self-respect and respectability, so that the best men may not dread the association. The day for drunkenness and ruffianism in our service has gone by, and it is high time the last vestiges of it were stamped out. The American man-of-war's-man should be made to feel that by becoming such he does not cease to be a citizen, but retains all the rights and privileges of his citizenship, and is bound to perform all its duties and to meet all its obligations. Such men, on the expiration of their service, would be eagerly sought after to fill many places in civil life which demand the exercise of qualities developed by the training they have received; and in case of war the country would enjoy the benefit of their immediate service. I believe it quite possible to raise native-born enlisted men to a position of dignity and respectability commensurate with their high calling, and to secure thereby an exceptional degree of efficiency.

In a country like ours, where personal success and advancement is supposed to depend entirely upon individual effort and merit, where a free career is offered to talent, and full scope given for vigorous growth, there should be no impassable barrier between the position of the officer and that of the enlisted man. Before 1878 there was practically no promotion for the enlisted man of the Army beyond the position of a non-commissioned officer, all vacancies not filled by the graduates of the Military Academy being generally given to young men in civil life with little or no military experience. The law now requires that all vacancies in the grade of Second Lieutenant shall be filled by appointment from the graduates, so long as any such remain unassigned, and any vacancies thereafter remaining shall be filled by promotion of meritorious non-commissioned officers; accordingly, quite a number have been promoted from the ranks, and nearly all have proved worthy. The selections are carefully made after due probation, the candidate being required to pass two examining boards—one a local board, and the other a general board ordered by the department. Worthy young men often enter the Army in the hope of securing these prizes, and their presence helps to elevate its tone.

I think the legislation for both services should be on parallel lines, as far as practicable, particularly with reference to emoluments and rewards; the number of such promotions must in any case be small, and the varied requirements and strict examinations must make them difficult. Still, they ought to be possible in the naval as well as the military service of a republic like ours. It is certainly an anomaly that a young American seaman is cut off from all hope of receiving a commission in our Navy, whatever may be his services, his talents, or his abilities. If it were possible, it would be exceptional, but that is no reason why it should not be open for men of exceptional capacity and ambition; while such a reward would raise the tone of the men and be of inestimable value in stimulating the zeal of the whole service.

The high qualities of the officers must be carefully guarded and maintained, for as are the officers, so will be the Navy, and the spirit of the former animates the latter. The soul of the Navy is in its officers, and an especial value is rightly placed upon education, because it is the basis of noble qualities. Yet we ought not to cling exclusively to scientific education, but also duly regard qualities of heart and character. It is not absolutely necessary that the men intended for any profession or calling should all be turned out

of exactly the same mould, and Nature's rough school affords abundant facilities for developing the needed brain-power to master the various questions we have to encounter; so it is possible those who have gained their knowledge by experience, and learned to rely on their own resources, may make good officers. At all events, the way should be left open, and the effort will have a beneficial influence. And I venture to think there are those who would not shrink from the labor of preparing themselves for any examination, however difficult. If, in time, no enlisted men can be found worthy of the great honor of being advanced to commissions, it must, in some measure, be the fault of those who have had it in their power to raise the intellectual and moral tone of our men, and have failed to do so. If it is declared that the crews of our war vessels, in whose keeping, at times, is the honor of their country, are thoughtless, drunken, immoral, and totally unfitted to be elevated to commissioned rank, the guilt for this great shame must reside somewhere, and it is high time we set about remedying the evil.

A navy gathered from the slums of our seaports, and from the ranks of the tramps and vagrants, is repugnant to the national pride, and does not inspire confidence in its reliability. There are thousands of respectable and patriotic young men in the country who would make excellent sailors, and who would gladly enlist in the Navy were it not almost considered disreputable to do so. The body of enlisted men of the service should be composed of persons superior in station and education—men sober, moral, diligent, and accustomed to reflect. To such men alone should be committed the honor of our flag.

The measures recommended in what are termed the Schley bills, that were introduced in Congress during the past winter, are most excellent and necessary to establish and assure our "blue-jackets" in their just rights.

The maintenance and treatment of the enlisted man should make him proud of his rank, pleased with his duty, and fond of the service. Above all, he should know and feel assured that in case of being disabled or taken ill he will not be abandoned or cast off, and that those who are dependent upon him will be provided for should he die in the service. This knowledge will give him a confident feeling of security, and make him a faithful, fearless servant.

Short enlistments are more attractive to the men, but long-time service is more advantageous to the Government, and we must accommodate, as far as practicable, these differing interests. Our ships usually

cruise abroad for three years, though they are sometimes kept in commission for a longer period; yet this is exceptional, and should never be the rule. I do not believe in recommissioning ships on foreign stations. It is not economical or conducive to health or efficiency. After a large number of people have been crowded into so small a space for three years, in trying climates, it is time to renovate and renew their abode more thoroughly than can be accomplished while it is occupied; moreover, the ship should be refitted and replenished at home.

When men are first embarked they have frequently been already enlisted from six months to a year. Then great expense is entailed in transporting them home for discharge on the expiration of their enlistment before the end of the cruise. This breaks up the organization of the ship and involves continued changes in the company. Men are enlisted abroad to fill vacancies, which is a great mistake, for they are usually beach-combers, pier-head jumpers, and foreigners speaking with difficulty only a few words of our language, and perhaps never having seen the country under whose banner they have enlisted. When our ships are filled with continuous-service men, all this may be avoided by encouraging the men to re-enlist at once on the expiration of their service, wherever they may be, on the assurance and definite agreement that they shall have three months' leave on their return to the United States.

It frequently happens when men are paid off at home they find it inconvenient to re-enlist within three months after discharge; and that is really a very narrow limit to allow. I would permit the enjoyment of a continuous-service record when a man enlisted within a year after discharge, and allow the three months' gratuity and all the privileges now enjoyed. Great pains should be taken to assist the men in accomplishing their continuous record, and no obstacle not absolutely necessary to secure the Government against loss and to maintain the efficiency of the service should be thrown in the way. It is no small thing for a man to lose all the benefits of such service when nearing the end of his career, and every care should be taken to help him on. One who has struggled successfully through a long term of years to maintain a good record in the Navy, looking to the reward, is deserving of every consideration. The same qualities which have made him successful here would in all probability have made him comparatively independent elsewhere. He must have suffered much and risked much, have passed many years in exile,

and served in climates unfavorable to health and vigor, besides foregoing comforts enjoyed by the humblest class of laborers on shore, and holding always his life a ready sacrifice on his country's altar.

When we have a better class of men we can secure a higher order of petty officers; and in this particular we are weak. We need a class of superior leading men, standing between the crew and the officers, who are reliable, trustworthy, well trained and efficient. Two classes of these men, after careful selection and due probation, should be warranted petty officers by the Navy Department, just as our non-commissioned officers of marines are now appointed. And these appointments should not be taken away from them except by sentence of court-martial. Then these men should be respected, supported and encouraged in the duties of their office. They could relieve the officers of many details and minor services, and would be valuable aids in the training and disciplining of the crew. Our petty officers as a body do not, at present, in any way as they should, fill the place in our organization which the non-commissioned officers occupy in the Marine Corps. And we very much need and feel the want of such a self-respecting body of petty officers.

One of the Schley bills provides for permitting sailors to deposit their savings and receive interest on the same. Something of this kind has been for a long time in operation in the English Navy and in our own Army. It is a very important measure to be introduced in our service, and will have good effects which perhaps are not apparent at first sight. If it were extended so as to provide savings banks for our apprentice school, the influence would be good. These school banks are now very common in many countries, particularly in France, where they are utilized to inculcate a spirit of foresight and economy, and to train the children in practical habits of thrift. Such savings banks are needed in our Navy. Their object is to train men in provident habits. The real end of such banks is the moral training of our naval children, and they have already accomplished great things with children of a younger growth. Thrift is a virtue slowly attained, and cannot be commanded at pleasure.

The evil in which our sailors indulge of squandering their wages in rioting and wantonness is known to us all, and the savings banks would in a great measure deprive them of the facilities for this, and prevent much vice and intemperance, if the spirit of economy were properly inculcated in their early training. On this inculcation of

thrift as a part of the educational training of our young sailors. depends in a great measure not only the welfare of the service, but the independence, dignity and happiness of their own future lives.

In our organization the exigencies of war will naturally bring out defects which a time of peace could never discover. It is always easier to point out defects than to define just what remedies are best suited to correct the evils. A free interchange of views and opinions, however, should do much to throw light on these matters, and I do not know of any more appropriate place to discuss the affairs which are of vital importance in our business than the arena which this Institute affords. We must consistently and steadily work out the perfection of our own organization, and our reforms must come from within. Now that a faint, glimmering hope of having a new Navy dawns upon us, this seems a propitious moment for renewed activity on our part, and I hope we shall lose no time in putting ourselves in the position of "the strong man, armed, whose house is at peace." While the multitude of our countrymen are developing the material resources of our rich inheritance, the proud privilege is given us of devising devices for its defense. The people have laid the strong foundations for and are building up a mighty country, while they have selected us to assist in guarding it. And I believe whatever we shall agree together to ask touching the necessities for our service will be willingly granted. But it seems so difficult for us to agree together.

DISCUSSION.

P. A. Engineer W. F. WORTHINGTON.—*Mr. Chairman and Gentlemen*:—I would like to point out some objections to parts of the paper just read. The writer says: "The modern fighting ship is dependent upon engines, as the old-fashioned man-of-war was upon sails, and the officers of the latter, with their subordinates, were able to care for their vessels in all the exigencies of service, although themselves not expert shipwrights or riggers or sailmakers. So in the present day officers of the modern fighting ship must be able to care for all her belongings without aid of a special class of officers who do nothing but look after the engines and are available for no other service." First, there is an inaccuracy in the statement of the case. While it is true that *all* the officers of the ship were not experts, he must admit that among them were the carpenter, an expert shipwright; the boatswain, an expert rigger; and the sailmaker, an expert in his line. Moreover, the analogy does not hold good, because the care of the marine engine, including repairs, is a far more difficult matter than the care of sails and rigging.

Referring to naval cadets, he says: "When the vessel is under steam they have charge of the engines." I presume he means they stand "engine-room" watches under supervision of engineers. If any one present knows of a case in which they have done the duty for any length of time with no engineer on board, I ask to be corrected.

Naval cadets at the Academy make some good drawings and do some good work in the machine shop in this way: The best instruments and tools are put into their hands, they are told how to proceed, and closely watched and instructed during the whole time. Few or none of them become good draughtsmen or machinists, that is, men who could be trusted to do the ordinary work of draughtsmen and machinists without assistance. If such men are given steaming watches at sea, and drills and boat duty in port, how can they increase their skill in either of these branches? When are they to learn to make the necessary drawings, now made by the assistant engineers, for repair work to be done in foreign machine shops? How are they to know if the prices charged are extortionate? to form a correct opinion as to the ability of the contractor to do the work in the time allowed, or to judge if the work has been properly done?

I disagree with the writer when he says: "Ultimately an officer might be detailed as chief engineer, just as now he is selected for navigation, and he need not know how to design or build an engine any more than the navigator must know how to design and build his chronometer or compasses, or the officer of the deck must be able to design or build the sails or spars." Here, as before, the analogies do not present a fair view of the case. One of the principal duties of the chief engineer is to be able to repair any part of the machinery that may break in such a way as to disable the engine. The first difficulty is to remove the broken parts without causing further damage. He

cannot do this without knowing the several methods in which it is customary to put together such pieces, and then judging which method was used in the case in question. He cannot depend entirely upon his set of drawings, for the very detail required may have been omitted, or, as frequently happens, the method of doing the work may have been changed and no note made on the drawings. His next problem is to replace the broken parts by others equivalent to them. He has not the complete outfit of tools and appliances at the command of the engine-builder, and therefore cannot simply produce a copy of those pieces. If he does not know how the pieces were designed, he can form no correct judgment as to which peculiarities of form, material and finish were essential and which not so, and therefore cannot produce pieces that will answer their purposes. But suppose there happen to be on board duplicates provided to supply the places of the very ones broken. The spare parts cannot be put into position without an intimate knowledge of the details of construction of the engine and ability to read intricate drawings, an ability not acquired by many of the present graduates of the Naval Academy, and not likely to be picked up hereafter on shipboard. With the simple machinery now in use at sea, breakdowns often occur which the united skill and knowledge of the chief and his assistants (from four to ten) cannot repair. How much oftener would this happen with the complicated engines of the war ship of the near future, cared for by men who had never seen an engine built and did not know anything of the principles which govern its construction!

The navigator does not need to know how to "design and build" a chronometer, because an ordinary chronometer will run well during the cruise without repairs; several of these instruments are carried to provide for accidents, and there are many more watchmakers than engine-builders in seaport towns. With regard to compasses, several are carried; they do not easily get out of order.

Moreover, the writer says: "The office of designers and builders is finished when the completed article comes into our hands." It would be most desirable if this were the case, but in the present state of marine engineering a complete engine cannot be built to run on indefinitely, like a chronometer. In support of this statement I refer to the frequent accounts of breakdowns given in the daily and technical papers, and to the still more frequent breakages of which we do not read, because it is to the interest of all concerned to say nothing about them. Many of these accidents arise from faults in design, construction and materials, and many more would occur but for the forethought of the experienced engineer, who discovers and provides against the evils of such defects. I have only touched upon the need of a good engineer in time of peace. Further on the writer says we should not have a peace Navy and a war Navy, but the organization should be on a war basis. I agree, and therefore when the machinery of a ship has been damaged in action on a foreign station, is it not worth while to have on board the most ingenious and intelligent and best informed engineer that can be procured, to avoid as far as possible the expense and delay of returning home? Would not a man who understood the business in every detail, embracing design and construction, be more

likely to be able to repair efficiently the machinery than one who had only a superficial knowledge? Were not the ships on our blockading squadrons frequently saved from returning North for repairs by the superior knowledge of one engineer, when another had thought such return necessary?

The writer says we are told "a man-of-war's-man of to-day is not a mere seaman, but a trained warrior. He is an accomplished artillerist, a skilled rifleman, a trained swordsman, a practical electrician, an experienced machinist and a superior torpedoist, rolled into one." We may be told this, but cannot be asked to believe it until we are shown at least one specimen of such an accomplished man. I do not admit that the number of specialists should be reduced, because the combined experience of foreign services has led them to continually increase the number. But if, without any experience of our own to guide us, we decide to reject the results of theirs and to reverse their policy based on it, I do not believe we can ever have less than three classes of officers—the line, the engineers, and the surgeons.

Captain FARQUHAR.—*Mr. Chairman and Gentlemen:*—Naval officers are unanimous in the opinion that some reorganization of the Navy is necessary, but just how this can be done is what we are anxious to know. The author advances some general ideas, all of which have much merit, as might be expected from so distinguished a source.

I think, however, that the plan of a commission to execute the duties of Admiral of the Fleet is, to say the least, very objectionable. As I understand him, this commission is to deal with the fleet—its *personnel*, its organization, its equipment, and its construction. Nothing, in my opinion, would be accomplished by such a commission, because its members would never agree. It would be far better for the Secretary to have as his adviser one officer of ability and rank—one who would be independent of the bureaus. "Too many cooks always spoil the broth." This officer should give all orders by order of the Secretary of the Navy, and be responsible to him alone. He might be the Chief of the General Staff.

The idea of taking officers from the enlisted men is, in the abstract, a good one, but hardly practicable. It would be impossible for them to pass such examinations as are now required for line officers, particularly such an examination as is passed in graduating from the Naval Academy. Besides, we are mustering out every year graduates for whom there are no vacancies. I think this will always be the case, for the supply for our small Navy will continue to be greater than the waste by casualties. I still hold to the argument I made in the Prize Essay of 1885, that the positions of warrant officers—boatswain, gunner, carpenter, and sailmaker—are what the enlisted men should aspire to.

We can never have the best material for the seaman class until we take for apprentices lads who are much better off by coming into the Navy than they were on shore; lads who have no homes; boys from orphan asylums and other similar charitable institutions who want to make their way in the world.

Captain Cooke deserves the thanks of the Institute for keeping the subject of reorganization before the public, and he has my best wishes that success may attend his efforts.

Commander HOFF.—*Mr. Chairman and Gentlemen:*—It is not my intention to discuss the very important and interesting paper we have heard read, but rather to make a few remarks confirmatory of the ideas expressed by the lecturer on the necessity of, 1st, Naval Administration by Naval Experts; 2d, A General Staff. To these two I must add a few words upon a third division, which in the opinion of most of the enlightened European nations forms a preparatory school for the proper performance of the duties of the other two, a Naval War College. We can always count, I fancy, upon a civilian performing the duties of Secretary of the Navy; and although such a condition of affairs would not be tolerated for a moment in any industry which expected to be successful, still our duties, which keep us away in some other part of the world from our fellow-citizens, will probably prevent our being sufficiently well known, or from having sufficient political influence to be put in the ministerial chair of our marine.

Granting, then, that we are to have a civilian Secretary, the argument of the lecturer that we must have a naval head who will be over the bureaus and under the Secretary is not to be controverted. It is the one thing that we in the Navy must put all our efforts into play to procure. This naval head can be one officer, or it can be a committee. I incline to the single man. In a board one man always rules; this is notorious. Although in the multitude of counselors there is wisdom, still where more than one compose the head, the greater is the division of responsibility; and this is something we must avoid. The lecturer's remark that the acts of the chiefs of bureaus should not carry with them the same force as those emanating from the Secretary is most true. It has been this clause in the law which has worked us so much harm. Given originally as a foil to cover the expenditure of money, so as to be within the statute, it has grown to be the sharp sword of several little Secretaries—swords which are generally clashing, to the detriment of the well-being of the Navy.

Not only would the administration be over the *material*, but the *personnel* would be taken care of. The true status of an officer before a board to examine him for promotion would be shown by an officer appointed by the administration to represent the best interests of the Government. Under such a condition of affairs only the worthy would rise. The forcing of the bad or worthless element out of the service could be arranged, so that younger officers could rise more rapidly, and the enlisted man who deserved it could take his place on the warrant officers' list at a very much quicker rate than at present.

As head of the Intelligence Department, the administration would take care that a fairly large expenditure of money was made *in* the Navy, so that officers could gain experience in those questions of the day upon which intelligence had been collated. This work should be carried on at the War College. The War College and the duties of the General Staff are mutually dependable, reflexive. At the War College the duties are such as to prepare officers in the practical portions of their profession, with such little theory as is necessary to an intelligent understanding of the subject, so that, to fill their positions as intelligence officers at sea, their minds are enlarged and quickened

to comprehend what is going on about them in foreign or home naval scientific work. Again, the reports from those officers, formulated at the Intelligence Office, should become the work to be investigated at the College. No administration is possible without a General Staff. No General Staff can exist without a special training.

I am glad to say that this year's work at Newport has been most satisfactory and pleasing to those who have the practical higher education of the naval officer deeply at heart. The motive of this institution may be described as intending to teach practically to the *many* the handling of the weapons of war, and to stimulate the *few* to develop them still further. But this further development must be by some post-graduate course, perhaps best here at *Alma Mater*. But the War College can only point the way to this few: it is not its province to instruct in this regard.

As to the practical results of its work, I may mention something of direct bearing on the General Staff. If we are weak in a naval way, we cannot give up all idea of a naval defense in case of war. So it remains to find out the best we can do. After a lecture on the subject, the Tennessee was ordered to defend herself as best she could against a torpedo attack; the War College to attack with the best means the class could devise and command. The Inspector of Ordnance in charge of the torpedo station was asked to umpire the affair, and to have the officers under him act as judges. After the attack, each party wrote its account of what happened, and what would in its opinion be the best defense of, and an attack upon, the Tennessee with the means at hand in our Navy. These reports probably, with the criticism on the attack and defense by the judges, form the very best thing that can be done by our Navy on this question, and fill the first pigeon-hole in the General Staff Office. Next summer, with improved material, this information may be very much modified, but the last information will always be on file.

We may not obtain such an administration for some time as our lecturer has sketched out for us, but I am certain that it is the thing to work for; for no success is possible without such an office. Our shores might be lined with our men-of-war, but still we would have no Navy. We officers, who consider ourselves the peers of any who tread the quarter-deck, are, after all, only instructed as a general thing, in one antiquated third of the science of warlike offense—the use of smooth-bore guns. Even this instruction, a branch of naval tactical science, has been heretofore taught by an ordnance organization. Ordnance has only the same relation to gunnery that naval construction has to seamanship.

Without statute can a naval administration be erected in the Navy Department? Our lecturer says that it can, and shows the way.

Let me tell you a little bit of history, perhaps not known; but it reads like a romance. The war of 1812 came upon us with the Navy, as at present, the football of the nation. Still its record was most honorable; its officers were men the mention of whose names still stirs our blood. They are dead now; here are their winding-sheets about us. A timid President, a civilian Secretary of the Navy, had determined, as, perhaps, the President and the Secretary of

the Navy in our next affair will determine, that the ships should all be laid up, their crews drafted into the army, and that they and their officers should garrison the seacoast forts. Stewart, Bainbridge, and I think Hull, it might have been some other captain, were in Philadelphia. They immediately started to Washington to see what they could do to prevent this cowardly piece of work —this traitorous, dastardly action on the part of the Government. On the way down, so the letter from which this history is drawn says, they determined that they would petition the Secretary to rescind the orders dismantling the ships. If this failed, they would petition the President; if this latter failed, they would, as a committee, storm the halls of Congress! What matter to them if they were besieging the Government without form of law? Their profession had been learned under Preble in engagements with Algerian corsairs; they had languished in Tripolitan prisons. Men they were who loved the sea, and the sea knew them. Now their birthright was to be stolen from them. They, a board of self-constituted naval administrators, would fight against the unlicensed encroachment of their craven superiors.

It was July, and the three men arrived at night. The next morning they called upon the Secretary before he was up. He said that he would see them at the Department. They saw him, but with unfulfilled wishes; in time they turned away. There was nothing to be gotten from him. They had permission to see the President. They called at the executive mansion; the President was absent; he would not be back until Monday, and it was now only Saturday afternoon. They went back to their scorching lodgings, and so far were these men from being disheartened that they decided not only must their petition be granted, but that they must have a complete scheme for a naval policy to offer the President. From that afternoon until Monday morning they wrote; the pen was never idle. Bainbridge said two lay out the window while the third wrote. Here, in a country town, although a capital, in a scorching room, was the first General Staff duty in the United States Navy accomplished. Without sleep, Monday morning saw the men at the White House. The President was seen, the petition read. The President asks the question, What could possibly be done with the ships, should his orders be rescinded? His answer was in the paper which was handed him, and which saved the Navy to our country. Their point was well made.

So, in the sweat and vigil of the pitiless heat of summer nights and days, did these determined men write the first page of the most glorious chapter in the history of our country. Do the spirits of these mighty men still live in us? If it is so, let us be up and doing!

Captain YATES.—*Mr. Chairman and Gentlemen:*—The paper of Captain Cooke suggests many ideas to me that I have entertained before. I agree fully with what he says regarding the necessity of a commission to assist the Secretary in the technical details of the service; in fact, so firmly am I convinced of the necessity of such a course, that I am doubtful of any permanent improvement in the condition of the service until a board or commission is instituted by law with authority to act in the details of the service, and to be

held responsible for the counsel it gives to the Secretary, and, so far as this is followed, to be held responsible for the condition of the whole.

Neither time nor space will permit me to give my reasons for this course; nor can I do more, for the same cause, than say I think it impracticable to make one person capable of being shifted from the position of Executive, Navigator, or Watch Officer to that of Chief Engineer. In other words, to obtain excellence in either profession one must devote too much time to one exclusively to become expert in both. For this reason it is my opinion that after the first two or three years at the Naval Academy, cadets should be permitted to select their corps and be educated accordingly; all to be given the necessary knowledge of all branches to be of the greatest use in battle or times of emergency.

In all that Captain Cooke says regarding the apprentice system and the necessity of having trained and respectable seamen to man our vessels, I fully agree. It is to be borne in mind that not only would these apprentices come to the country's aid in time of war as seamen, but should the increase of ships, gunboats, etc., for any reason be so great as to render necessary the appointment of junior officers from civil life, what class would be so competent to pass the required examination, or be more efficient, than these same apprentices, who were discharged at the age of 21 years, or after a longer period of service?

It is true that an impassable barrier exists to the promotion of the enlisted man to a commissioned officer. This, in times of peace, cannot be otherwise, when the knowledge and training necessary to make a naval officer are considered. The Naval Academy is open to boys in all the walks of life, and there is no privileged class in this respect; and the officers come as distinctly from the people as if promoted from enlisted men. The barrier might be opened in time of war to those who have served a certain number of years as apprentices, are capable of passing a determined examination, and have the recommendation of the commanding officers with whom they have served. If this privilege were made public, it would be something of an allurement to retain the apprentices in the service, and do much to satisfy the ideas of justice of many of our very democratic countrymen.

As additional inducements for apprentices to remain in the service, I recommend the raising of the seaman class to a level with that of the special and artificer classes in the matter of pay. Without dwelling more upon this subject, as I have specially called attention to it in remarks at the meeting of the Newport branch of the Institute last spring, I would ask officers to examine the pay-table of the Navy, particularly the pay of the seaman class ranking with machinists, yeomen, etc. There are no more of the former on any vessel than of the latter, and not as many. The increase of pay recommended would be but slight, and the seaman apprentice would not think that, in the estimation of the country, aside from all sentiment, the seaman class is deemed the least valuable of any in the Navy.

Offenses and punishments should be classified, as far as practicable, and then published, and the greatest amount of liberty on shore consistent with discipline and efficiency should be given. In the new vessels improvements in the men's quarters have been made; still it appears to me there is room for more.

Petty officers should be rated and disrated by the action of a board of three officers, subject to the approval of the commanding officer. The outfit of clothing should be paid for by monthly instalments of about one-sixth or one-fourth of the pay of the recruit, and during the period of such payments he should be considered as out of debt, so far as monthly money and liberty are concerned. The mattress and blankets should be given to the recruit gratuitously. Savings banks should be instituted on board the ships, as recommended by Captain Cooke, and by Captain Farquhar in his prize essay of last year. The warrant officers, except the carpenters, should be selected from the apprentices. This should be made obligatory by law.

The pension laws should be so amended that seamen or persons in the naval service who enlisted as apprentices and served their term of apprenticeship shall, after 21 years of honorable service after attaining their majority, be allowed to retire from the service, in times of peace, with a pension equal to 50 per cent. of the pay of the rating held at the time of their discharge; those who have earned good-conduct badges should receive, in addition to the 50 per cent. of their pay mentioned, 5 per cent. of the same pay for each badge so received up to this period of their service. In accordance with the Department's General Order No. 327, the pension of a man who should receive a good-conduct badge at the expiration of each of his terms of enlistment would be 80 per cent. of his pay in active service.

The continuous-service certificate and the good-conduct badge regulations work admirably, and I have had some experience in knowing how highly the former are held by their possessors, since I have been in command of the New Hampshire, in my endeavors to obtain good instructors for the apprentices. As this vessel is included in the Bureau's order relative to the employment of continuous-service certificate or general-service men on stationary ships, men who possess the continued-service certificate would rather go to sea than lose them and their privileges, although some leave their families on shore and give up on this ship some of the highest rates in the service.

In my opinion, the whole service should be open to the selection of instructors, petty officers and seamen for the training squadron, including the New Hampshire; for in the training squadron the first impressions and lessons, so long remembered, are given.

The system, as at present established, is, in my opinion, the best. The conditions of society in our country are such that the boys should not be taken younger than 14 years. They should not remain on the stationary ship longer than the six months now set. This is long enough to teach them how to live on board ship, and give them a good start in their drills. Desertions are more frequent than desired, though the majority of those who have gone lately are, I am pleased to say, the worthless ones. I believe if the law would permit the discharge of a boy when a board reports he has no aptitude for the service, from whatever cause, even to positive dissatisfaction, without regard to the state of his accounts, and would try by a general court-martial a few deserters, the effect would be very beneficial. Keeping them in the service until they are twenty-one, or are out of debt, is a great expense to the Government, and their

influence upon the other boys is extremely pernicious. In the New Hampshire the greater part of the weeding out should be done, and from my experience two or three months are sufficient to enable one to judge of a boy's capabilities.

From my experience with the apprentices thus far, I must say that I am more than pleased. Their boy nature is no different from that found in the best boarding-schools in the country, and if it is surrounded by proper influences, and the consideration shown to youth and youthful pranks that a healthy discipline will allow, the apprentices can be moulded into a body of the best seamen in the world, in whom the country will have a just pride and the service find the greatest aid to efficiency.

Lieutenant-Commander STOCKTON.—*Mr. Chairman and Gentlemen:*—The interesting and suggestive paper by Captain Cooke brings to the front in a direct manner for discussion various subjects, some of which of late have been the cause of wide and frequent discussion in public and private; while others, though doubtless at times the subject of conversation, have not been presented before in this public manner to the members of the Institute and the officers of the service.

The constant interest in all matters likely to advance the service which impels the writer of the essay to publish his views should be appreciated by all, whether called upon to agree with or dissent from his various propositions. Remarks upon a paper like this must necessarily be critical, and suggestive only to a limited degree. Those now offered by me are intended to touch very briefly upon a few of the subjects treated, and not as a comprehensive review of the paper. Fuller treatment would be offered only when demanded by the proper circumstances.

The author of the paper has referred concisely to some of the defects of the present organization of the naval service and the Department, particularly in that the Navy, after a logical, systematic, and military organization afloat, finds in the central administration and Navy Department no professional, naval head and commander-in-chief. The Lieutenant-General of the Army, commanding the Army of the United States, with the President and Secretary of War as his immediate superiors, has no counterpart in the Navy; and often the Secretary of the Navy is forced to have a substitute, who, without the rank, responsibility, or emoluments, becomes, for the time, the actual, though not the nominal, commander-in-chief of the naval service. This has been the condition of affairs for many years.

The essayist proposes to put this place in commission—to have a board or commission to execute the office of Commander-in-Chief. It seems strange, after the many failures of the past, and the lessons of political administrative and military history, to propose again to invest a board with executive authority and duties. Take the early history of our own country; that rope of sand, the Articles of Confederation, had as an executive authority a body of men, while the framers of our Constitution wisely vested in one person, the President, the execution of the laws and the administration of the policy of the nation.

The French have a single head, in a naval sense, in the Minister of Marine, who is an Admiral of the Navy, professionally competent; and, in the cumbersome English Admiralty, the various members of the board in its workings are subdivided into heads of naval and civil departments.

Fully aware of the many schemes and plans to rectify this obvious defect, I venture briefly to suggest one more, which seems to me both natural and logical. Let the naval head of the service be the actual professional head. Perpetuate the grades of admiral and vice-admiral; require by law the retirement of these officers either at sixty-two or sixty-four. Promote to these grades, as well as to rear-admirals, by selection; no one to be selected unless as rear-admiral he has commanded a squadron at sea, and has at least two years to serve in the grade; and then make the Admiral of the Navy the chief of the *personnel* and the head of the naval service in the Navy Department. Let the official and actual head be combined in the one person. The Army has this system of promotion, and has been the better for it; it is a necessity in war, and good administration in time of peace.

The Secretary of the Navy, with the proposed Bureau of Construction, Material, and Repair and the Bureau of Supplies and Accounts under his direct control, both to a great extent civil in their nature, would find his energy and time fully occupied.

The Admiral of the Navy, chief of staff to the Secretary, in immediate command of the fleet, would have in charge the *personnel* and all matters directly connected therewith; in other words, under and by direction of the Secretary he would have charge of the recruiting and training of officers and men, the inspections and drills, the detail, the discipline, and, finally, the movements of vessels and squadrons. In all matters concerning the *personnel*, he should be superior to the chiefs of bureaus. The Vice-Admiral could be placed in naval command of the Pacific Coast of the United States, including the Navy Yard at Mare Island, and some attention might in this way be officially called to the almost entire want of military and naval defenses of that coast, especially the Northwestern frontier and its great waters.

Great stress is laid upon the importance of a General Staff; its utility is not overrated, but, after all, it is only an adjunct, and should be for the use of the Admiral, the service, the Secretary, and, if need be, the President of the United States.

The essayist does well to call attention to the necessity of the reduction of the non-combatant element on board ship; it should be restricted, both among officers, petty officers, and men, to the smallest practicable number. Whatever number of specialists and experts may be needed on shore for the designing of ships, ordnance, machinery, and electric plant, the officers on board ship should be familiarized only with the *use* of the material furnished, and should not attempt to become competent manufacturers and expert designers of the same. The number of persons needed to design and superintend the construction of material for the Navy will be extremely small, and they should be relieved in some way from the active duties of the service. It will not do to attempt to make expert designers of all of the members of the various corps and grades of seagoing branches of our profession.

As the paper advocates, the apprentice system should be extended, and it should be the principal, if not the only, means of supplying enlisted men to the service; but the urgent necessity of affording sufficient inducement and attractions to retain the men thus trained must not be overlooked. These inducements the service does not at present offer. There is so little present or prospective stimulus offered for progress in efficiency that the retention of the best men and their choice of a career in the service cannot be counted upon. No graded increase of pay is offered as a reward for increased activity and more extended training. One can hardly glance down the three *parallel* rows of the pay-table of the petty officers, etc., contained in the Navy Register with any degree of patience. Take the pay alone of chief boatswain's mate, who is the leading blue-jacket on board ship, and who takes the place of boatswain in the smaller vessels of the service. His pay of $35 a month is the incentive an apprentice has as a reward for the attainment of that position. There are nineteen petty officers of the artificer and special classes who receive more pay than this most important combatant petty officer. A more glaring defect does not exist to my knowledge in the service.

Every opportunity should be taken to urge upon Congress the passage of what the essayist terms the Schley Bills. When passed they would mark a long step in advance for our men, and if accompanied with the rectification of the pay of the petty officers and trained men, which does not require legislation, a new era would be opened for the enlisted men of the service, to induce them to serve more faithfully, more permanently, and more honorably under that flag which owes so much to the exertions of their predecessors.

Commander SCHLEY.—*Mr. Chairman and Gentlemen:*—In most discussions touching naval reorganization, it appears to me that many officers confuse its organization with its administration. The paper under review recommends a commission to assist the Secretary in matters of its *technique*, but the intended scope of its authority is not defined, except to relieve the Secretary of many technical details of his office. As all of the technical details of the Department are now, by general order, performed by the bureaus, the suggestion would add more machinery to the Department without simplifying in any respect its business working.

The paper then proceeds to state that the "author's time would fail him to recount the many instances of conflicting authority and cross-purposes which have occurred in the dealings of the various branches of the Department ashore and afloat"; and, therefore, the organization of the Department is condemned. What he condemns is administrative, and could result under any organization that lacked proper administrative discipline. There is no law defining departmental administration, and I am quite free to say that there ought to be none. The Secretary, if a good business man, will always attend to this part of it. The methods of the Department business should be left entirely to the Secretary, as at present, that he may introduce any system he may elect. If, after trial, one plan fails, it would be unfair to force him into Congress for its repeal before another could be tried. To my view there is something eminently proper

in leaving the Secretary independent in these things. As he is responsible to the President for the administration of his Department, he ought to be free to control its business, to conform it to the method of successful private corporations. There can be no doubt that the Secretary has struck upon the chief defects of the Department in his reformation of its business administration. When he shall have completed these, as contemplated at the present time, and extended them into the service afloat, there will be less cause for complaint than now.

There is nothing in the law to prevent the Secretary from calling to his aid an officer whose duties would be to advise him in all matters relating to the movements of the fleets; and I do not doubt, if he felt its need, that he would do so. But as he is likely at all times to have around him in the Department officers of some merit in their profession, I cannot well see the importance of adding one other, whose entire duty would be to perform the only remaining duties which the paper leaves for the Secretary. It is difficult to account for the constantly expressed desire for change of naval organization, so common in our profession, upon any other theory than that, our professional lives being made up of constant changes of station, we are thus really educated to restlessness. Since the establishment of the Navy Department, somewhere about the year 1800, there have been no less than three different organizations in it; all in turn have been overthrown, and now this paper advocates still another, which it styles a commission—really, I assume, a sort of Admiralty Board. It might be well for most of us to read a recent book on the English organization entitled "The British Navy in the Present Year of Grace, by an Undistinguished Naval Officer," and the reply to it by a "Lieutenant, R. N." The former is unquestionably overdrawn and somewhat spiteful; but when supplemented by the information of the reply, there can be no question that we should gain nothing in making a change in our organization to assimilate the British. If their system of organization is susceptible of the complaint and mismanagement charged, it might be well to look well before we leap into anything like it. But in view of the suggestions of this paper, and those of the two books cited, it would be interesting to know which of the two is right, if my assumption is correct that a commission really means a Board of Admiralty.

Every Commander-in-Chief abroad has his General Staff, and I quite agree with the paper that it might be well to require each member to gather up every scrap of information coming within his reach relating to the latest advances made by foreign nations in all things affecting their offensive and defensive preparations. These reports should all find their way to our "Intelligence Bureau," to be published, as now, for our information and guidance.

I quite agree with the author of this paper that all officers of the Navy, except surgeons, whose duties are distinct, ought to be educated for command. It is certain to happen in future naval combats that the destruction of life will be immeasurably greater than ever before by reason of the multitude of rapid-firing and machine guns now composing the armament of modern war vessels. If this be true, then we need a larger reserve to fall back upon than was necessary when we possessed fewer means to destroy life than now. In this view

the education at the Naval Academy is most proper, and from that institution should come all the officers in future. Such titles as engineer, marine, and pay officers should disappear in their temporary assignment to these duties for the cruise. Surely good organizations would require this concentration of the official *personnel* of the service, that no excuse could exist for defeat that might come to us now from the destruction of all combatant officers, while a large percentage of the non-combatant class were left untouched, but untrained to manœuvre or fight the vessel.

It must be admitted that with the disappearance of sail, or with its use in a subsidiary sense only in our war vessels, the education of officers and the training of men must differ from the practice of former days. The new and higher seamanship as applied to steam vessels of great power means the most intimate acquaintance with their tactical power, their various contrivances for gun control, their torpedo outfit for attack and defense, their interior arrangement and construction, their electric attachments for comfort or for use in attack or defense; all these things are to be acquired, in addition to the indispensable knowledge of taking care of the vessel at sea.

Turning now to the enlisted men of the service, there can be no doubt that too much importance cannot be given to the selection of Americans for service on board our national vessels. But if it is remembered what the possibilities buttoned up in every American boy's jacket are, it will be apparent that we must provide for their future in no indefinite way. In other words, if we expect American boys to make their homes in the Navy, their living conditions are all to be improved, as you improve them in mental fitness for the newer duties. When worn out or injured in the service, they must be cared for in no uncertain manner.

When vacancies happen in the grades of boatswain, gunner, and sailmaker, those American boys best fitted should be promoted to fill them. And when they have reached a certain length of service in the ranks, they should be retired in the same way that officers are retired, with 75 per centum of the pay of grade they reach on retirement. Savings banks should be established for their benefit, to invite and cultivate habits of thrift in money matters. When filling the position of petty officers their tenure should be for the cruise, and their reduction should not occur without a court-martial. It should never depend on the caprice of commanding officers.

The articles of war should be modified, so that much which is copied from the old English system, applicable to a period of time away back in the past, should be expunged as belonging rather to the days of the rack and torture. As you educate and train men, less punishment is needed in governing them, and their own self-respect is your best assistance. It seems to me that if we teach men to respect themselves, they will be better prepared to respect their officers and the lawful authority under which they serve.

This appears to me the direction our reorganization should take. In this we are all supposed to be experts, and I am convinced if we shall turn our attention to this important practical question and give our best efforts to the solution of these matters in the interest of our American sailors, all the diffi-

culties complained of in this paper will disappear as mist before the sunshine. I see no other solution of this problem, though we may theorize upon it until the end of time.

Commander HARRINGTON.—*Mr. Chairman and Gentlemen:*—I am unwilling to pass without dissent the views which have been expressed by one of the officers present with regard to the office and employment of the naval engineer.

The care of the engines and boilers of a war vessel is purely mechanical duty. At sea, the lubrication of the machinery; the prevention of heating in bearings; the regulation of the supply of water to boilers; the firing; the stopping, starting, and reversing of the engines at the signal from the officer of the deck, and all the other usual duties of the officer in charge of the engine room, are practical matters in which unlettered men become expert. In port, the examination of engines, fitting brasses, cleaning boilers, and all repairs to machinery are solely the work of machinists, boilermakers, coppersmiths, blacksmiths, and other artisans, whose handicraft has been acquired in manufacturing shops and on board ship. During the Civil War the management of the engines of our vessels was very largely in the hands of men, brought from machine shops or from the merchant marine, who had little knowledge of books and scientific steam engineering. They understood the working of boilers and engines; they could handle tools and repair machinery; and they did their work well; but they were not men of scientific attainments nor even of liberal education. The younger line officers of the Navy, graduates of the Naval Academy, have been appointed, under the orders of the Navy Department, to perform duties in charge of the engines of our war vessels while under steam. Many of us can testify to their rapid acquisition of knowledge and their ultimate capability and efficiency when in charge of the engine and fire rooms. The engineers of the great steamers, which cross the ocean at high speed and without stopping during a voyage, are not scientific men. The majority of them spring from the shops of shipyards and continue to discharge during life the laborious duty of running a ship's engines. When accidents to machinery occur on board ship, the senior naval engineer directs what repairs shall be made, but he does not make them, for that is the machinist's work. Indeed, the engineers of the Navy at sea are now chiefly engaged in superintending the performance of the machinery. A few of them stand watch in the engine room, but the greater part of this duty is done by machinists and by young line officers.

The more highly educated the professional engineer, the more averse he will be to the routine duties of the engine room; and with reason, for it seems irrational to educate a man in all the higher branches of the science of steam engineering and then put him to do a life-work of running engines, in which work his scientific acquirements will prove of little use. Some experience in the engine room, in working engines and boilers, is necessary to the complete education of a steam engineer; but, if running engines is to be his chief duty in the Navy, a scientific education is unnecessary; if he is to be employed in higher duties, in the superintendence of machinery afloat and of the manufacture and design of machinery on shore, he must be relieved from the ordinary

watch duties and the daily work of machinists on board our ships. High professional research and daily mechanical employment are not compatible, except in rare instances. We do not find, often, science and mechanical skill combined in one man.

I conceive that the engineers of the Navy should be employed chiefly to superintend the machinery of cruisers. Some may be stationed on shore to inspect the construction of machinery. A few, and only a few in our small Navy, will be required to engage in designing and construction. The great majority of the corps should find their work in charge of the engineer's department of war vessels; and for this duty their professional education should be extended. They must have experience in the workshops and in the management of engines and boilers. They should be practical men, accustomed to consider all difficulties with machinery and to suggest ready remedies, and competent to direct the efforts of the engineer's force so that the engines may develop the best results with certainty. They should be able to judge, from a scientific point, the performance of machinery and to project improvements upon it. They should be experts in machinery of all kinds and competent to prepare reports upon new engines which they may view abroad.

One or two professional engineers on board each large ship should be sufficient. To run and repair the engines of our ships we require a body of machinists, under the orders of the superintending engineer of each vessel. These machinists should be schooled in the machine shops and in working engines and be expert in the use of tools. They should do the work which is unsuited to the rank and acquirements of scientific engineers and which professional engineers do not perform. Proper grades for promotion, permanence of appointment, and longevity pay, will secure reliable and capable men for this service.

I do not agree with the essayist that the employment of line officers in the engine room should be continued to such an extent that they may be ultimately detailed for duty as chief engineers. The line officer's occasional employment in the engine room is useful in its results; but I consider that we shall not draw for each ship from the body of line officers, whose minds must be largely directed to other vital acquirements, officers of the special knowledge desired in the superintendent engineer I have described.

The non-combatant element in our ships should be reduced, eliminated if possible. By non-combatant element I mean that large class of men on board our ships who do not take part directly, and are not trained to take part, in working the great guns and other weapons. At general muster the long line of non-combatants is appalling. Our crews should be homogeneous in nationality, in class, in capability, and in training. The able seaman will be in the future, as in the past, our force, our trusty agent, and every other type of men on board should be assimilated to him. The engineer's force should be trained at the great guns, at the secondary batteries, with small arms, and in the boats. Few servants should be enlisted; indeed, they might be taken from the sailor class. Abolish paymasters' clerks and naval cadets at sea, and put the remaining steerage officers into the wardroom. In conflicts be-

tween ships, ramming is most probable; ships will come together; and, for such an event, every man in a ship should be trained, each with a proper weapon, to keep his own deck or to go on board the enemy.

The argument of homogeneousness extends to the marines and would exclude them from a vessel of war. It does not seem wise to have a special class of men for one arm, men who do not work in all the duties of the crew. The marines are now employed on board chiefly as sharpshooters and as sentinels over Government property and refractory sailors. But the seamen of our Navy must become sharpshooters, and they must learn to guard themselves and their ships. A proportionately large part of the crew must be employed in the engine room; outside of it there should be but one class of men, the able seamen, who should be entrusted with every duty and office of the ship under the commissioned officers.

I have outlined an opinion, in which many officers concur, based upon the principle that no man should be retained on board who is unable to perform one, and, usually, more than one, of the essential duties of the vessel of war. The elementary training should be done in separate ships. There is no place in a ship prepared for war for naval cadets and clerks, who take up the room of officers; nor for boys and servants, who exclude as many fighting men ready for any work with any weapon in any part of the ship; nor for yeomen, writers, schoolmasters, ships' corporals, lamplighters, tailors, barbers, buglers, printers, painters, etc., unless they are seamen or form a part of the fighting force.

These suggestions of the employment of machinists and of homogeneous crews spring naturally from the practice existing in foreign navies.

With regard to the employment of engineer officers, we find that Great Britain has a greater number, proportionately, than any other country. The number of engineers appointed to the vessels of the British Navy serving at sea in April of the present year runs as follows—viz.: In each of twenty-nine ironclads and large vessels, whose displacements range from 10,820 to 3080 tons, and of 8600 to 3500 horse-power, one chief engineer and three assistants form the regular allowance; supernumerary assistant engineers are appointed to a few of these vessels for detail to other ships or for special service, so that we find one ship with eight engineers, one with seven, seven having six engineers each, seven having five, and thirteen with four only; for twenty-four other vessels, whose displacements range from 9330 to 1760 tons, and horse-power from 6750 to 1830, the allowance is one chief engineer and two assistants; in each of six other vessels, whose displacements range from 3560 to 2120 tons, and horse-power from 2190 to 1145, there are one chief engineer and one assistant; and one engineer is assigned to each of sixty other vessels, of which twenty-three are from 900 to 1500 tons in displacement and 900 to 1400 horse-power, the remainder being of less than 900 tons. It appears, however, to be the policy of the British Admiralty to reduce the number of engineers serving at sea. The total number of engineers decreased from 974 in 1872 to 777 in 1880, and in the latter year about five-sevenths were serving at sea. The total number has been further decreased to 687 in the present year. On

the other hand, the number of engine-room artificers increased from 176 in 1872 to 612 in 1880. Writing in 1882, Sir Thomas Brassey said: "Since the introduction of artificers into the (naval) service their number has been steadily increasing, while the engineers have been proportionately reduced. There seems reason to believe that the movement might be carried considerably further. * * * * The mechanical branch requires a certain number of superior officers. They should be formed into a staff corps, in some respects answering to the French *génie maritime*. A staff officer of naval engineers should be attached, as in the French Navy, to every flagship, and one or two should be appointed to each first-class ironclad. In the subordinate ranks skilled mechanics would be more useful."

In the French Navy, the marine engineers (*génie maritime*), ninety-three in number in 1884, do not serve at sea. They form a corps of constructing engineers, drawn from the graduates of the Polytechnic School at Paris, who also graduate from the Cherbourg School of Application for Engineers, and their duties are wholly in designing ships and engines and in superintending their construction and repair in the dockyards and at private works. Another corps, called machinists (*mécaniciens-en-chef et mécaniciens principaux*), furnishes a small number for the largest cruising vessels of the navy. The machinists numbered ninety-six in 1884, of which forty-five were afloat. These are commissioned officers, though they do not bear the name "engineer," nor do any of them attain higher rank than that of lieutenant-commander. Most of them rank with ensigns. They are the superintending engineers of the ships in which they serve abroad. The men who have charge of the engines in nearly all vessels of the French Navy bear the title machinists (*mécaniciens*) and have the rank of warrant officers. They have been trained in the management of boilers and engines at the School of Machinists in Toulon. Their education in practical steam engineering is very thorough; in mathematics, mechanics, and physics their instruction is elementary and has special reference to steam engineering. These machinists become eligible, upon passing certain examinations, for the lowest grade of commissioned-officer machinists.

In the German Navy there is a small corps of mechanical engineers, who are charged with the care of engines on board the larger ships. The members of this corps are graduates of the school at Kiel. The engine-room watch duty is done by machinists, who are eligible for the school at Kiel. The engineer corps of this navy is a separate body, and its members do not serve afloat. The corps numbers sixty, about half of whom are engaged in constructing ships and the remainder in building engines.

Italy has adopted the French plan of education. She has a corps of constructing engineers, who do not serve at sea, numbering in 1883 seventy-three. There is a body of engineer mechanicians, which had seventy-eight members in 1883. These machinists are trained in the school at Genoa, and they manage the engines of the fleet, which has now the largest ironclads in the world.

An examination of the courses of study at Toulon and Genoa shows that the French and Italians have adopted an effective system of supplying their fleets with practical machinists. The scientific-engineer corps are not open to

these machinists. The British system provides a small number of engineers for construction duties, and a body of well-educated engineers, in addition to engine-room artificers, for service afloat. It does not appear, however, that any country has settled definitively upon a plan of placing scientific engineers in the engine rooms of ships for watch duty; machinists seem to be preferred for that purpose.

THE CHAIRMAN.—*Gentlemen:*—The comprehensive character of the essay, at least so far as concerns the *personnel* of the service, together with its suggestions of many other subjects than those it considers at length, makes it a paper covering points upon some of which every officer has decided views. I think the character and extent of the discussion here to-night show this to be the case.

I shall limit my remarks in closing the discussion to two points. The first has been suggested by the remarks of Commander Hoff quite as much as by the essay. I refer to the duties of the "General Staff," as outlined by the author of the paper. We have no such office in the naval service, and the duties which belong to that office are not now performed. As the author states, the principal duty of such an office would be to prepare for war. In the sense in which the word "preparation" is here used, we are totally unprepared, and further than this, no provision is made that we shall prepare at any future time. It is not the specific duty of any one or any office to make such "preparation" as is here contemplated.

I cannot better explain my meaning, which I am confident was also the meaning of the author, than by an illustration: Suppose that war were declared between the United States and Spain, or Great Britain, or any other enemy or possible combination of them. I think it will be at once conceded that such a war must be largely, if not entirely, a naval war. To whom would we turn for advice and guidance? To whom could we turn? Is there an officer in the service, or does there exist any official authority, prepared to assume control and direct what is to be done, to say whether we shall act offensively or defensively? Would the President and his Cabinet decide such questions? Manifestly, the responsibility would rest there; but can the Cabinet be reasonably expected to be familiar with the numerous problems involved? It is the province of the statesman to anticipate the difficulties, and by his wisdom and firmness to prevent war; but when diplomacy has been superseded by a state of war, the military and naval service should be prepared to meet the new condition of affairs and carry them to a successful issue. Although the President and his Cabinet must bear the responsibility of the course adopted in case of war, they have a right to expect that the necessary technical knowledge will be at hand to assist in their councils. Now, I believe that the technical knowledge which would be required under these conditions could not be found.

Consider for a moment what is comprehended in proper preparation for war. Among other things, we should know the naval strength of our enemy, and this knowledge should be particular and specific as regards guns, armor, speed, and draft of water; we should know at all times the position of every portion

of this force; we should have a complete knowledge of the resources of our enemy—that is, his ability to increase his fighting powers in men, guns, and ships. We should know the position and condition of his coaling stations, the extent and character of his merchant marine and its lines of traffic. We should know the weak and strong points of his coast defense; the character of the defenses—whether guns, mines, or torpedoes, or a combination of these. We should know the character of his harbors and the location of all arsenals and storehouses.

It is needless to say that an equally particular and accurate knowledge of our own resources would be required. All this information can now be furnished by the Office of Naval Intelligence, and this knowledge of facts may be considered the tools with which the strategist may commence his work.

The accumulation of such information may be considered as the first step in the way of preparation for war. Next must follow a careful study of the whole field, to decide how most effectively to use our own force and most certainly to paralyze the efforts of the enemy. In case his fleet is scattered, we should aim to destroy it in detail. If an important port is without the necessary naval defense, it would be the time to concentrate upon it.

On the other hand, we should anticipate and provide for similar efforts being made against our own weak points. We should have exact knowledge of the internal state of the country of our enemy, as to whether the government is likely to be warmly supported under given conditions of warfare, or whether a decisive blow against him would awaken the patriotism of the people, or prematurely discourage them. We should know what nations would prove his allies under given circumstances, and the same knowledge of the strength and vulnerability of every possible ally must be, in like manner, studied. A little consideration will show that here is a vast field for study. It is not a subject that can be solved as one would solve a problem in science or a problem in chess. The student must have the whole resources of the Government at his command. It is the grand problem of war, and the elements which enter into it are widely varied, and in number equal to that resulting from the combination of all human passions and the material forces which act upon them. It will also be readily seen that the number of problems may be very great; the number of nations that may become our enemies, and the various combinations which might be formed against us, would make the number great.

To study and solve these problems would be the duty of the General Staff, as I understand that term. At any rate, it is the duty of the naval service to concentrate upon these questions the best ability and most painstaking thought possible. It is a large question; ample means and every facility should be provided by the Government to master it. And I am confident that those who will undertake this work will receive every encouragement when their aim is understood. It was to meet this want that the War College was founded. It was for the study of the science of war that this latest naval *school* was established. The scheme was to assemble a class of officers and propose such a problem as I have referred to—a war between the United States and another country—and develop a plan of action to be followed in the given case. After

studying the question in all its bearings, which might require months of reading and research, a perfected plan was to be drawn up and filed for future use. A plan of action in case of a war with one country having been decided, another country would be taken and studied in the same way, and a similar completed and detailed plan prepared. You may say that such plans must vary from time to time, as the factors vary. This is true; but a careful plan would provide for many contingencies, and when any arose which had not been anticipated, the plan must be revised. An able chess-player forms his plan of attack and provides for his defense while he anticipates many possible moves. Something unforeseen may decide him to change his plan, but he must never be without one.

Such study as this will be an excellent school of preparation for war, and I believe that the plans resulting from this study would supply a great deficiency in our organization. Such study had not been undertaken elsewhere, and great credit is due the distinguished officer who recognized its need, and who has done so much to establish it. This scheme is not yet in working order, for, unfortunately, it has not been understood by the service, and (through misapprehension of its aims) it has been vigorously opposed. The War College is not a post-graduate course of the Naval Academy in the sense that it is a continuation of the instruction given here. It aims to teach, or, more properly speaking, to furnish facilities for the study of, subjects that are taught nowhere else. It is not a fanciful scheme to increase the book-knowledge and add to the already endless examinations of our naval officers, but it has been evolved from the necessities of the service.

When sharp and sudden war comes upon us there should be a well-considered plan of action to cover every probable condition of affairs, and there should be officers at hand whose study of strategical questions had prepared them to supplement, if necessary, the plan in question. If these plans were ready, and there were officers whose intelligence and skill in such matters were well known, their advice would be sought and followed when war came. If the number of ships and guns were small, the greater would be the necessity for such careful preparation, and the Navy would have done its part.

Nor would it be alone in time of war that such a state of preparedness would have its influence. In time of peace it would develop in the legislators of the country such a confidence in the foresight and wisdom of those controlling naval matters that they would trust their judgment and be guided by their advice as they have not been in times past.

Thus much I have said about the War College, and its functions in a proper organization of the naval service, because I fear that it has not been understood. I think it is our duty to encourage and advance it in all possible ways. It is not a rival of the Naval Academy; it has a different field; and I sincerely hope that those who have its affairs in charge will confine its work to the original plan, which comprehended the Science of War, International Law, and Naval History. This is a course which demands mature minds for its study.

The second point upon which I venture to remark, and this time to differ with the able author of the essay, concerns the education of our naval engineers, and the necessity for them in our naval organization. The author of

the essay, quoting, says: "A man-of-war's-man of to-day is not a mere seaman, but a trained warrior. He is an accomplished artillerist, a skilled rifleman, a trained swordsman, a practical electrician, and a superior torpedoist rolled into one"; and then adds: "This long list of accomplishments necessary for a modern man-of-war's-man shows how impossible it is to indulge in specialties on board ship." Admitting the necessity of this array of accomplishments—and I even think it should be materially increased in number—I would draw an entirely different inference from this necessity; in other words, the great variety of acquirements necessary among the officers of a ship shows how necessary specialists have become.

I think the soundness of this statement must be admitted, if we stop to consider how comparatively simple a machine a man-of-war was, even a few years since, as compared with the latest type of an ironclad man-of-war. If we could be assured that we had reached the end of development; that no other accessories would be added, that no other complications of machinery would be devised; that triple- or quadruple-expansion engines would not become necessary; that submarine warfare would not be added to the other means of attack; that the development of guns and torpedoes had reached a standstill; then we might each hope to become experts in every branch of our profession. But, far from any such assurance being possible, we know that the reverse will be true. Each day will see applied to our profession fresh principles of science and new applications of well-known principles. New engines of warfare will be invented, present ones will become greatly changed. Special types of ships will be built for special purposes, embodying special features, and to accomplish special ends; and this differentiation will be carried to a length that we cannot now anticipate. How, then, can we hope to keep pace with all these changes unless we divide up the work, as it were, so that our combined acquirements will cover all the ground? Much more difficult will it be to initiate and perfect these prospective improvements in our profession, except by encouraging specialties.

I do not wish to be understood as advocating a division of the officers of the line into corps, who shall each devote himself to a special branch of the profession and know nothing of the others. On the contrary, I think the acquirements of an officer ought to be extended, and should at all times comprise such a general knowledge of his profession as will enable him to fight his ship and use intelligently every appliance of it. But, above and beyond this, every officer should aim to be an expert in some branch of his profession in which he may act as a guide and critic for the service.

Consequently, if engineers were once useful to the service, they have now become necessary, and will be in the future indispensable. On the other hand, I am convinced that the number of non-combatants should be reduced to the smallest number consistent with the efficient performance of duty. On board of any ship the number of engineer officers should not exceed two. There is no necessity for marine officers, and probably no necessity for marines. The paymaster needs no clerk. One doctor is quite enough for most ships, and when there are two there should be no apothecary. These are a few of the reductions that should be made.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

ON THE STUDY OF NAVAL WARFARE AS A SCIENCE.*

"*Science is applied knowledge.*"

By Rear-Admiral S. B. Luce, U. S. N.

Under date of May 3, 1884, the Secretary of the Navy appointed a board of three officers to "report upon the subject of a post-graduate course for officers of the Navy."

The board so appointed met, and, after careful deliberation, reported, under date of June 13, that there was "not only a reason, but an *absolute necessity*," for the establishment of such a school as contemplated by the order, the report dwelling most particularly on the importance of the study of war and international law. Much stress was laid upon the subject of war as the leading study of the proposed school. The board expressed the opinion that "a cogent reason for such a school was that there might be a place where our officers would not only be encouraged, but *required* to study their profession proper—war—in a far more thorough manner than had ever heretofore been attempted, and to bring to the investigation of the various problems of modern naval warfare the scientific methods adopted in other professions." And this idea of the study of war according to a certain prescribed method pervades the whole report. It is the central idea of the plan of operations, the very cornerstone, as it were, of the War College.

The report of the board was adopted, and in October the Navy Department issued the following order:

* Introductory paper read at the Naval War College, Newport, R. I., Sept. 6, 1886.

"General Order No. 325.

"NAVY DEPARTMENT,
WASHINGTON, *October* 6, 1884.

"A college is hereby established for an *advanced course* of professional study for naval officers, to be known as the Naval War College. It will be under the general supervision of the Bureau of Navigation. The principal building on Coasters' Harbor Island, Newport, R. I., will be assigned to its use, and is hereby transferred, with the surrounding structures and the grounds immediately adjacent, to the custody and control of the Bureau of Navigation for that purpose," etc., etc.

"WILLIAM E. CHANDLER,
Secretary of the Navy."

No immediate steps, however, were taken to carry out the order.

During the Second Session of the Forty-Eighth Congress the Senate adopted a resolution (Feb. 4th) calling upon the Secretary of the Navy for information in regard to an advanced course of instruction for naval officers. In answer the Secretary wrote, under date of February 11, 1885, as follows: "The reasons which have controlled the action of the Department are to be found in the recognized necessity for *an advanced course of military and naval education* in the United States. There are now existing three schools for the purpose in the Army and one in the Navy. The latter is at the Torpedo Station at Newport, where a class of officers is assembled for a few months in each year for instruction in the art of manufacturing and using torpedoes and torpedo explosives. The constant changes in the methods of conducting naval warfare imposed by the introduction of armored ships, swift cruisers, rams, seagoing torpedo-boats and high-power guns, together with the more rigid methods of treating the various subjects belonging to naval science, render imperative the establishment of a school where our officers may be enabled to keep abreast of the improvements going on in every navy in the world. The Torpedo School only partially fulfils the imperative requirements. The College is intended to complete the curriculum by adding to an extent never heretofore undertaken the study of naval warfare and international law and their cognate branches." (See Senate Ex. Doc., No. 68, Forty-Eighth Congress, Second Session.) From this it would appear that the War College is not, in the estimation of the Department, for a post-graduate course merely, as that term is generally understood,

but for the higher and much more comprehensive purpose of a greatly advanced course of professional instruction.

Now, it must strike any one who thinks about it as extraordinary that we, members of a profession of arms, should never have undertaken the study of our real business—war. For members of the naval and military profession it should be not only the principal study, but it should be an attractive study. War has been called a game, and as a game it possesses great interest to a majority of men, while to a certain order of minds it has a positive fascination.

We find in civil life men who love to study the campaigns of the great captains of history; who read the life of Alexander the Great, made up wholly of his campaigns, with the eagerness others peruse the pages of romance, and who follow Cæsar through Gaul, and Hannibal across the Alps, with the keenest interest. No one can read the series of manœuvres, the play and counter-play of Turenne and his great opponent, Montecuculi, resulting in the untimely death of the former, without a thrill of admiration for the skill displayed by these two well-matched adversaries. And, although confined entirely to the land forces, such campaigns are replete with valuable lessons to the naval officer. Marlborough, Frederick the Great, Napoleon, Wellington, and many of the great military leaders of our own country, have left us a rich legacy of many a skillfully played game which furnishes practical illustrations of great principles. It is for us, here and now, to familiarize ourselves with those principles, that we too may be ready to apply them when called upon to take a hand in the game.

Now, science is contributing so liberally to every department of knowledge, and has already done so much towards developing a truer understanding of the various arts, including that of the mariner, that it seems only natural and reasonable that we should call science to our aid to lead us to a clearer comprehension of naval warfare, as naval warfare is to be practised in the future. Steam tactics and naval warfare under steam are comparatively new studies, and readily admit of modern and scientific methods of treatment. The formation of the line-of-battle, composed of large ironclads, carrying heavy guns and auto-mobile torpedoes, the use of the ram as an independent arm, and the seagoing torpedo-boat and its place in the order of battle, are subjects which require the most careful consideration, and may well excite on the part of the naval officer, indeed *should* excite, an intelligent curiosity or inquisitiveness.

Indeed, we may go further, and say that the naval officer who does not seek to inform himself on these points is indifferent to the most important branch of his profession. That the whole subject is new and fresh and worthy of our most careful study is to be learned from the fact that the great naval powers of Europe still regard steam tactics as an unsolved problem. Thus we have the charm of novelty in our researches and a stimulant of a happy solution of a great problem.

What we need is, first, a clear conception of the problem itself, and then a solution of it so grounded in immutable principles as to admit of no doubt of its correctness. But it may be asked, "What is science?" and "How are we to regard as a science naval warfare, with all its various and complicated conditions?" and "How are we to treat such a subject in a scientific manner?"

In order to answer this very natural question, let us first understand what is meant by the word "science." Webster defines science to be "knowledge duly arranged, and referred to general truths and principles, on which it is founded, and from which it is derived." "In point of form," says Sir William Hamilton, "it has the character of logical perfection, and in point of matter the character of real truth."

"A science," says Dr. Francis Lieber, "is a branch of knowledge or collection of ideas systematically developed according to principles peculiar to the subject-matter itself. A science is independent within its own sphere. Everything is worthy of being scientifically investigated; that is, worthy of being investigated as to its essentials, separately and for itself, with a view of arriving at principles and laws. Every principle and law thus arrived at extends the sphere of knowledge, expands the human mind, increases the stock of civilization, and is emphatically useful."

Buckle defines science as "a body of generalizations so irrefragably true that, though they may be subsequently covered by higher generalizations, they cannot be overthrown by them; in other words, generalizations which may be absorbed, but not refuted."

Both of the two last definitions may be illustrated by the history of the development of the physical sciences. By a series of experiments in chemistry many interesting and useful facts were discovered; but it was not till the generalizations of Lavoisier linked those facts together that the laws which govern the properties of matter were brought out. It was by this inductive method that chemistry was raised to a science.

In its earlier history geology was a crude mass of independent facts. But Cuvier applied to the study the generalizations of comparative anatomy, and co-ordinated the study of the strata of the earth with the study of the fossil animals found in them. Thus he was the founder of the science of geology.

Astronomy furnishes a still more forcible illustration. Hipparchus, Ptolemy, Copernicus, and Galileo, each in his own time, made certain discoveries and demonstrated certain truths in relation to the movements of the heavenly bodies, and of the earth itself. And Tycho Brahe, the Dane, far exceeded them all in the vast accumulation of observations of the stars. He undertook, in short, to catalogue the fixed stars, a labor originally essayed, though in a much ruder manner, by Hipparchus. But while Tycho Brahe himself knew not the real value of his own work, Kepler, generalizing from the great mass of observations, was led to the discovery of those three great laws relating to the planetary system which won for him the proud title of "Legislator of the Heavens" and opened the way for the final generalizations of Newton.

Taking its rise in the fanciful dreams of astrologers, astronomy has now become the most exact of all sciences. "By employing the deductive weapon of mathematics we can compute the motions and perturbations of the heavenly bodies; and by employing the inductive weapon of observation the telescope reveals to us the accuracy of our previous and, as it were, foregone inferences. The fact agrees with the idea; the particular event confirms the general principle; the principle explains the event; and their unanimity authorizes us to believe that we must be right, since, proceed as we may, the conclusion is the same; and the inductive plan of striking averages harmonizes with the deductive plan of reasoning from ideas."*

Now, naval history abounds in materials whereon to erect a science, as science has been defined and illustrated, and it is our present purpose to build up with these materials the science of naval warfare. We are far from saying that the various problems of war may be treated as rigorously as those of one of the physical sciences; but there is no question that the naval battles of the past furnish a mass of facts amply sufficient for the formulation of laws or principles which, once established, would raise maritime war to the level of a science. Having established our principles by the inductive process, we may then resort to the deductive method of applying those princi-

* Buckle's History of Civilization in Europe.

ples to such a changed condition of the art of war as may be imposed by later inventions or the introduction of novel devices.

For a very simple and obvious illustration we may take the state of shipbuilding during the early and middle parts of last century. The French ships-of-war were of superior model and their bottoms were sheathed with metal. The English ships-of-war were of inferior model and were not sheathed. The natural result was a constant gain of advantage in their sea fights of the former over the latter. The English ships were, on certain momentous occasions, so greatly retarded in their movements by the accumulation of marine growth, and their indifferent sailing qualities were of such great and manifest disadvantage to them in battle, and the fact is so often made a matter of historical record, that, by the method of generalization, we are enabled to lay down the broad principle that *speed is an essential element in naval warfare*—an axiom not needing an elaborate argument, but given as an illustration. This is the inductive system of proceeding from particulars to generals.

By reversing the operation and applying the deductive method of proceeding from generals to particulars, we deduce from the principle just stated the fact that the modern war ship must be modeled with special reference to speed, and must have her bottom protected from the fouling due to vegetable marine growth. Thus we arrive at a fundamental truth; and to disregard such teachings is not merely to commit a great blunder by shutting our eyes to the lessons of history, but it is to be unscientific in one's own profession, which, in these days, is to be culpably ignorant, if not criminal.

Nor are we obliged to go very far back for many important facts in regard to maritime war, on which we are to generalize. In our own very limited experience in war the battle of Port Royal furnishes a valuable illustration of the necessity of possessing a secure base of supplies within the theatre of war, and few naval conflicts have been so pregnant with results as that in which the monitor bore so conspicuous a part. As an illustration of that very important military element called the *moral effect* of a battle, it stands almost unrivaled.

The grouping together of a number of important facts gathered from the accounts of naval battles will enable the naval student who has acquired the habit of generalizing to lay down principles for his own guidance in war, and that is a work that each one can do for himself better than another can do for him. The passage from facts to principles in induction in its highest form is inspiration, says Tyndall.

Again, it has been said that the philosophy of method bears the same relation to science that science does to art. "The progress of every science is affected more by the scheme according to which it is cultivated, than by the ability of the cultivators themselves." Some men, like Tycho Brahe, without a Kepler to follow, "have consumed their lives in fruitless industry, not because their labors were slack, but because their method was sterile."

Hence, to elevate naval warfare into a science, as we now propose doing, we must adopt the comparative method; and, as Cuvier co-ordinated the study of geology with that of comparative anatomy, so must we co-ordinate the study of naval warfare with military science and art. That is the theory on which we are now to proceed; and it is desirable that each one of us should comprehend this theory in its length and breadth, its height and depth, for it is on such perfect understanding alone that success in our present undertaking can be assured. It is by the comparative method that we have been led to a knowledge of the most important phenomena of the science of life. As it would be impracticable to study the living action of the various organs of the human body, the physiologist has recourse to other means whereby to carry on his investigations. All vertebrate animals, being constructed on the same general plan of organization, with corresponding organs of the same character common to all—their nervous and vascular systems, digestive apparatus, organs of locomotion, and the rest—can easily be recognized and compared with each other. From the study of the brain of a pigeon, for example, Dalton was enabled to explain the functions of the human brain. From experiments on the horse, Matteucci demonstrated the rapidity of the circulation of the blood. Brown-Séquard and Velpeau, by experiments on animals, discovered the functions of the spinal cord. Bidder, Schmidt, and Dalton illustrated the process of digestion by experiments on dogs; and the action of the heart and the circulation of the blood were, by the same process, illustrated by Harvey. This gives us a hint pregnant with possibilities.

We have already referred, in passing, to the splendid results achieved by Cuvier through his adoption of the comparative method of investigation. Says Buckle: "By this union of geology and comparative anatomy, there was first introduced with the study of Nature a clear conception of the magnificent doctrine of universal change, while at the same time there grew up by its side a conception, equally steady, of the regularity with which the changes are accomplished, and of the undeviating law by which they are governed."

In his beautiful eulogy on Agassiz, Professor Le Conte, in explaining the comparative method of investigation (for the more general introduction of which he gives the great scientist high praise), says: "Anatomy only becomes scientific through *comparative* anatomy; physiology only becomes scientific through *comparative* physiology"; and we may add, without distorting the parallelism, that naval tactics, using that word in its more extended sense, becomes scientific only through *comparative* tactics. For, having no authoritative treatise on the art of naval warfare under steam, having no recognized tactical order of battle, being deficient even in the terminology of steam tactics, we must, perforce, resort to the well-known rules of the military art with a view to their application to the military movements of a fleet, and, from the well-recognized methods of disposing troops for battle, ascertain the principles which should govern fleet formations. Thus, from the known, we may arrive at something like a clear understanding of what is now mere conjecture. *It is by this means alone that we can raise naval warfare from the empirical stage to the dignity of a science.*

It is important that this should be understood. We lay so much stress upon this method of treating our subject that, even at the risk of overburdening the argument, let us refer once more to the methods of investigation pursued by the most advanced thinkers of the age. We have drawn our illustrations so far from the physical sciences. Let us now go to other departments of learning, and we shall see what the comparative method has done for them.

"It was supposed at one time," says Max Müller, "that a comparative analysis of the languages of mankind must transcend the powers of man; and yet, by the combined and well-directed efforts of many scholars, great results have been obtained, and the principles that must guide the students of the science of language are now firmly established.

"It will be the same with the science of religion. By a proper division of labor, the materials that are still wanting will be collected and published and translated; and when that is done, surely man will never rest till he has discovered the purpose that runs through the religions of mankind, and till he has reconstructed the true *Civites Dei* on foundations as wide as the ends of the world."

It has been by treating the subject of religion in a scientific manner that deep and hidden truths have been revealed, and passages of the Holy Scriptures otherwise obscure have been rendered clear and

full of meaning. Thus, as the author says, "the science of religion will for the first time assign to Christianity its right place among the religions of the world; it will show for the first time what was meant by 'the fullness of time'; it will restore to the whole history of the world, in its unconscious progress towards Christianity, its true and sacred character."

Speaking in another place of the science of language, he says: "People ask, 'What is gained by comparison?' Why, all higher knowledge is gained by comparison, and rests on comparison. If it is said that the character of scientific research in our age is pre-eminently comparative, this really means that our researches are now based on the widest evidence that can be obtained, on the broadest inductions that can be grasped by the human mind." "What can be gained by comparison?" he asks again. "Why, look at the study of languages. If you go back but a hundred years and examine the folios of the most learned writers upon questions connected with language, and then open a book written by the merest tyro in comparative philology, you will see what can be gained, what *has been* gained, by the comparative method." Reasoning thus, he advocates the comparative or scientific study of the religions of the world.

Lastly, we have the authority of Mr. Hutcheson Macaulay Posnett, who, in his *Comparative Literature*, says: "The *comparative method* of acquiring knowledge is . . . the peculiar glory of our nineteenth century."

Hence, we have not only comparative anatomy and comparative physiology, but comparative philology, comparative grammar, comparative religion, comparative literature, and why not, we ask again, comparative war, or a comparative study of the military operations of a sea army and a land army? Attention has been called repeatedly by various writers to the close analogy between military and naval operations. It has been successfully shown that among the ancients, or what has been termed the "oar period" of naval history, the military and naval tactics were as nearly identical as the nature of the elements would admit. The most distinguished soldiers of Carthage, Greece, and Rome commanded afloat, as occasion required.

Macaulay, in speaking of the English Navy of the time of Charles II., says: "No State, ancient or modern, had before that time made a complete separation between the naval and military services. In the great civilized nations of the old world, Cimon and Lysander, Pompey and Agrippa, had fought battles by sea as well as by land.

Nor had the impulse which nautical science received at the close of the fifteenth century produced any material improvement in the division of labor. At Flodden the right wing of the victorious army was led by the Admiral of England. At Jarnac and Mon-Contour the Huguenot ranks were marshaled by the Admiral of France. Neither Don John of Austria, the conqueror of Lepanto, nor Lord Howard of Effingham, to whose direction the marine of England was entrusted when the Spanish invaders were approaching its shores, had received the education of a sailor. Raleigh, highly celebrated as a naval commander, had served during many years as a soldier in France, the Netherlands, and Ireland.

"Blake had distinguished himself by his skillful and valiant defense of an inland town before he humbled the pride of Holland and of Castile on the ocean.

"Since the Restoration the same system had been followed. Great fleets had been entrusted to the direction of Rupert and Monk—Rupert, who was renowned chiefly as a hot and daring cavalry officer, and Monk, who, when he wished his ship to change her course, moved the mirth of his crew by calling out, 'Wheel to the left!' Coligny was a colonel of infantry when, in 1552, he was made Admiral of France, and distinguished himself at the battles of Dreux and Jarnac, and James II. served in the French army under Turenne, and received a thorough training as a soldier, before he was called upon to command the Channel fleet during one of the great Dutch wars."

About 1672 the French began to educate young men of good family especially for the sea, and England soon followed the example. In the process of time the two professions, the naval and military, became so distinct that everything of a military character began to be looked upon with contempt by those bred to the sea. The very name of "soldier" became among sailors a term of reproach, and when troops of the line were first placed on board ship they were made the subjects of endless ridicule among the rollicking sailors. Even to this day the older class of seamen despise "sojering," and look with contempt upon a "musket." This feeling was not confined to the seamen. It was shared by the officers, who prided themselves on their practical seamanship, and held military matters as beneath their notice. We have now reached a stage of progress which enables us to take such a broad and comprehensive view of nautical science as to avoid either of these extremes. While educating officers especially for sea service, they are yet taught the

military character of their profession; and the close analogy between the operations of a fleet and an army has long been insisted upon, and is now generally acknowledged.

Even under sail tactics Paul Hoste, and, later, John Clerk, the author of the "Essay on Naval Tactics," noticed the military character of fleet evolutions. It is not surprising, therefore, that early in the history of steam tactics there should have been a number of writers who called attention to the same fact. Admiral Bowles, R. N., remarked that we had "arrived at a new era, in which steam would enable naval commanders to conduct their operations on military and scientific principles," and Admiral Dahlgren observed that the principles of military tactics would hereafter enter largely into the manœuvres of a fleet. Sir Howard Douglas, referring to these several authorities, adds that "the celerity and precision with which steam fleets may execute any evolution whatever will hereafter allow the principles of tactics on land to be applied to the movements of ships on the ocean, with this advantage on the side of naval operations, that the inequalities of ground which so seriously embarrass the manœuvres of troops do not exist at sea." This is quite true. The movements of an army may be, and very often are, obstructed by the physical conditions of a country; mountains, rivers, and forests must often be taken into account in planning a campaign, and the lines of communication with the bases of supplies, the lines of retreat, and the topography of the country within the field of operations must necessarily control the question of the proper distribution of troops for battle. None of these elements enter into the discussion of the operations of a fleet.

But beginning with the terminology of elementary tactics, and passing thence through the school of the battalion to grand tactics, and, finally, to strategy, it will be found that there is so much that is common to both the land and the sea forces, that we may by the comparative method, readily and intelligently, not only formulate correct theories in regard to naval warfare under steam, but confidently lay down unerring principles for our guidance in the conduct of battle. Commodore Parker's "Fleet Tactics under Steam" is, as he himself tells us, "simply an adaptation of military to naval tactics." Woods Pasha, in a recent article on the naval tactics of the future, says: "It is hardly possible to glance at the development of the modern fighting ship without being struck by the analogy between military action afloat and ashore." Indeed, it would help

very materially in our investigations if we kept prominently in view that word *milites*, signifying fighting men, and thus have constantly before us the military character of our profession. We might then consider a fleet as a sea army, as the Latin races do, and adopt without reserve, as far as applicable, the tactical movements of the land forces for the management of an assemblage of ships-of-war. Such a step would have the advantage of clearing away or disposing of a great deal of useless material left over from the sail period, and enable us to bring to the consideration of our subject minds unembarrassed by obsolete formularies.

It would far exceed the limits of this paper, which is intended to be merely introductory, to point out in detail the close analogy between the operations of land and sea forces. Many illustrations will doubtless suggest themselves to the naval student who reads military history, and it is especially recommended that the members of the class under instruction should, each one for himself, as we pass through the course of lectures on military science, note the points of analogy as they come up and make careful memoranda of those principles of military movements which are applicable to a floating force.

By way of illustrating our meaning more clearly, we may give a few examples of the more obvious principles common to both services. Guibert, an eminent French writer on military science, has said that the art of fortification and that of field tactics are intimately connected with each other, and that the latter derives many of its principles from the art of constructing permanent fortresses. In both the important object is to dispose the parts, whether works or bodies of troops, so that they may afford mutual protection. He infers, therefore, that to be a good tactician a knowledge of military engineering is necessary. Now, these remarks apply with equal force to the naval tactician, for he too should so dispose the ships of his fleet that they may mutually support one another. Ships may be regarded as movable forts, and reasoned upon accordingly. "The inartifical practice," says Sir Howard Douglas, "of forming a fleet for battle in one long line, in which the ships are devoid of the power of protecting each other by reciprocal defense, and without a second line as a reserve, ought to be abandoned, as a corresponding practice with armies in the field has been renounced in warfare on land." The advantages of the *echelon* formation for an army and its application to a fleet have been so fully and ably set forth by Sir Howard

Douglas as to leave nothing to be added. The most striking illustration, however, is to be found in that peculiar method of attack to which Napoleon owed many of his victories on land and Nelson on the sea. It is expressed in that maxim which teaches the importance of so conducting a battle as to bring upon the point of attack a great superiority of force in such a manner that the enemy, even if numerically superior upon the whole, may be unable to succor the part so overpowered. The late Captain James H. Ward, U. S. Navy, in commenting upon this point, says that this same maxim, so fully recognized by military writers, was in the contemplation of Byng in 1756; of Hood at Basseterre Roads (St. Kitts), 1782, and was carried out by Rodney in his chase of the French in 1782; by Nelson at the Nile and at Trafalgar, and in a most remarkable manner by Perry at Lake Erie.

We have already laid down as a principle in naval warfare, clearly established by the method we have adopted for our investigations, that "speed is essential to success in war." This is true also in military science. Marshal Saxe declared that "success in war is due to the legs of the soldiers." The rapid marches which preceded the battles of Gunzburg and Elchingen, we are told, were the causes of the successes of Napoleon much more than those combats, brilliant as they were. To the bold and rapid movements which characterized the campaigns of Alexander the Great, Cæsar, Hannibal, Frederick the Great, and Napoleon are to be attributed their uniform successes.

But there was a certain mobility, as distinct from speed, peculiar to the troops of Napoleon, which rendered them easily handled by a master of the art of war. This too is an important quality in ships. It was the speed and activity of the Greek triremes that led to their victory at Salamis. It was to the light, swift, and quick-turning Liburnian galleys that Octavius owed his victory at Actium. The Spaniards of the Invincible Armada were astonished by the speed and handiness of the English ships they encountered in the Channel. The Duke of Medina-Sidonia said they seemed to leave the Spanish ships and approach them at pleasure. In one of his plaintive letters to Parma he wrote: "We cannot bring the English to battle, for they are swift and we are slow." The wretched sailing qualities of the Spaniards and their unwieldiness put them at a disadvantage for which skill and courage could not compensate.

Now, speed is a comparative quality. The English ships of that day,

though fast when compared to the Spanish ships of the Armada, were slow when confronted later on with the superior models of France. It was during the greater part of the eighteenth century that the speed and handiness of the French ships-of-war enabled the French admirals to practise those tactics which so long rendered the high fighting qualities of the English of no avail. To the quality of speed, then, we must add, as another deduction, the quality of mobility, handiness, or the property of quick turning. The ocean racers of the great Transatlantic lines, with lengths ten, and often eleven, times their beam, have great speed, but very limited powers for quick turning.

There is still another quality of speed, or, more properly speaking, celerity of movement (if we may make the distinction), which is common to both land and sea forces, but which belongs more to the personal character of the commander-in-chief than to the troops or ships under his command. "It was not the Roman army which conquered Gaul, but Cæsar," said Napoleon. "It was not the Carthaginian army which made Rome tremble at her gates, but Hannibal. It was not the Macedonian army which marched to the Indus, but Alexander. It was not the Prussian army which defended Prussia for seven years against the three most powerful states of Europe, but Frederick." The wonderful success of these great captains was due in a very large measure to the continuous celerity of their movements, to their great energy governed by an intelligent directive force.

In 1781 the English fitted out an expedition to capture the Dutch Colony at the Cape of Good Hope. De Suffren sailed shortly afterwards from Brest (March, 1781), fell upon the English squadron under Commodore Johnson, at Porto Praya (Cape de Verde Islands), and after a drawn battle hurried on to the Cape of Good Hope, where he arrived one month in advance of the English, thus fully securing the object of his mission, which was to thwart the designs of colonization by the English in that quarter. History is replete with such examples of celerity of movements both in the land and in the naval service.

Nelson's chase of the French squadron under Villeneuve forms a chapter in itself. In connection with mobility of the units of organization must be considered still another element of success common to both services, the potency of drill. The talents of the naval architect and the skill of the marine engineer and the labors of the ordnance officer will have been put forth in vain, if the squadron of fighting ships be not in efficient discipline and thorough drill. History teaches no more important lesson than this, and here again the two armies

stand on common ground. The Romans called an army *exercitus*, which also meant exercise. What a history in that one word! Frederick the Great paid more attention to mere parade drill than any modern general, to which fact he owed many of his victories, as well as his escapes from serious disasters.

"Unquestionably," says one military authority, "of two armies equal in all other respects, and equally handled by their commanders, that one must win which can manœuvre with the greatest rapidity and precision." And one of the most distinguished writers of the day on naval matters says, in speaking of the necessity of a school of practice in naval tactics, "The fleet most thoroughly drilled in naval tactics will have the greatest advantage in war."

To say that "speed," "handiness" and "drill" are elements essential to success in war, seems to be stating such self-evident truths as to need no demonstration. That may be true, but it is equally true that the examples of history which inculcate these lessons are being disregarded every day by nearly all maritime powers, and by none more than our own. They are of that class of truths which everybody admits, but nobody heeds. A certain English essayist says that "the best way of introducing any subject is by a string of platitudes delivered after an oracular fashion." We have taken the hint.

Captain Maguire, U. S. Army, following Guibert, shows the analogy between land and sea forces from the point of view of a military engineer. In speaking of the attack of forts by ships he says: "This attack by sea may be compared to a land siege. The fleet will first bombard the sea forts at long range, in order to silence their fire; thereupon it will approach nearer to the coast forts and batteries, in order to carry on with favorable chances the decisive fight intended for the complete subjection of the latter. Finally, it will turn its attention to those works more retired which bear upon the harbor entrance and its obstructions. This last act may be considered as entirely identical with the heavy and rapid fire of the siege batteries, which precedes the advance of the storming party. In case the obstructions consist of submarine mines, and the fleet must destroy them by torpedoes, this operation is identical with the counter-mining operations of a siege. Finally, as the storming of the breach is the crowning act of the siege, so must, or should, at least, the forcing of the harbor entrance be regarded as the last stage of the attack.

"This comparison leads us to the conclusion that the general

principles of sieges may be applied to attack by sea. In place of the ground in front of the works to be attacked lies the sea, which, with its depths and shoals, rocks, islands, wide and narrow channels, represents the more or less favorable field of operations of the attacking party; while the powerful ships, in consequence of their armor, are very strong batteries, which, after being once completely equipped, need no subsequent aid, and, in consequence of their engines, can constantly and rapidly change their positions.

"The ammunition supply of the ships will limit their action against a sea fort to the duration of a few days; and this, in connection with their great mobility, will give to the attack the characteristics of a short, rapid engagement."

But enough has been said to show the close analogy between the land army and the sea army to render further illustration unnecessary.

Having shown the system by which it is proposed to conduct the course of study in naval warfare, it is but just and proper to state, at the outset, that we are without instructors or even text-books. This should be distinctly understood. But we have an instructor in naval history to tell us some of the great lessons of the past; and we have an instructor in military science to teach those of us who are willing to learn what he knows of the general principles of that science. It is our part to learn what we can of them, to draw our own conclusions and to make our own deductions, and to apply the principles which they illustrate by the operations of past wars, both at sea and on land, that we may formulate our own ideas on the subject of naval warfare. By doing this we adopt the *comparative method.*

It is obvious from what has just been said that, while learning naval history and the military art and science from professors of those branches, we must be our own instructors in the naval art and science. Says President Bartlett, of Dartmouth College, in the *Forum* for September: "All higher education is essentially self-education. Teachers do not make the scholar. The impulse comes chiefly from within, and the student becomes the scholar when he ceases to confine himself to prescribed tasks or previous limits, and spontaneously reaches out beyond." If we are to learn this highest, noblest branch of our profession at all, we must be our own teachers, for as yet the science has no professors. We are the pioneers. Not only is it true that we have neither instructors nor text-books on naval warfare under steam, but there are no foreign navies to which we

can turn with confidence for instruction. In many of the essentials of an efficient navy, nearly every other maritime country has left us all but hopelessly in the rear. But in the theoretical knowledge of naval tactics under steam, it may be said that we all stand on common ground, with this advantage in our favor—that we are untrammeled with the traditions and formularies of an extinct period of tactics, and are, so far, free to prepare ourselves for a new study.

Let us glance for one moment at the state of "naval warfare under steam" as it was understood in England up to a very recent period. In an article on "Naval Tactics" which recently appeared in one of the most influential of the English reviews occurs the following: "There appears to be a pretty unanimous agreement, on the part of all those who have made naval tactics a subject of study, that the art has, in its revived form, scarcely advanced beyond the merest rudimentary conditions of existence. It is impossible not to be struck by the strange singularity of such a fact, if fact it be." We may here interject the remark that it *is* a fact.

"In an age in which the greatest scientific skill and mechanical ingenuity have been unreservedly exerted in perfecting the warlike efficiency of the military marine, the one art needed to develop to its fullest extent that truly wonderful efficiency has been strangely neglected and overlooked.

"The great tactical revolution caused by the introduction of steam propulsion has been either quietly ignored, or its extreme significance has been left to be pointed out by a small company of prophets, who have not, as yet, succeeded in gaining more than a partial hearing for the statement of their views." And further on the author remarks: "It is somewhat humiliating to reflect that, as yet, in spite of the immense progress made in every other branch of the naval art, the very stones wherewith to raise our tactical structure are, as has been well said, still unhewn. Some malignant fairy appears to have been slighted at the birthtime of that mighty fleet (the English Channel Squadron and steam reserve combined in 1872) which has won the admiration and has become the model of all the navies of the world. It possesses all the elements of perfection, but lacks one gift—the power to use it with effect." And the writer concludes: "We have as yet found out no proper system of tactics, *not because the invention of one is impossible*, but *because we have neglected to follow the roads which lead to it.*"

This is certainly very plain language, but we believe it to have

been absolutely true at the time it was written, some fourteen years ago—1872.

We may now come down to 1880. The Naval Prize Essay of 1880, by Captain the Honorable Edmund R. Freemantle, R. N., is still fresh in our memory. "If," says that able essayist, "we attempt to derive inspiration from the numerous naval writers who have studied the subject of a naval engagement between ironclads of the present day, we are startled at the wide difference of opinion expressed, not only as to the strength of various formations, but as to the manner of fighting which will be adopted. As a rule, strong assertions have been made and decided opinions given, based on necessarily weak arguments and weaker facts.

"A very general belief, shared apparently by foreign writers, has been that fleets will clash together in 'line abreast,' and that they will subsequently pair off to decide the action, forming a series of independent duels." Some of the best of the English naval essayists represent the "line abreast," as they term the line, as a very weak tactical formation. "On the other hand," he continues, "we have foreign authorities advocating the 'line abreast' as the only effectual tactical formation, and objecting to the inherent weakness of the 'line ahead' (column); while the English naval writer who has given most attention to the subject (Captain Colomb) prefers the 'line ahead' to any other combination." The group system of Bouet-Willaumez, the essayist treats with scant favor, though so strongly advocated by others. "The disagreement," he adds, "is not so much in the end sought for as in the means of attaining that end, Captain Colomb relying mainly on the GUN; the French writers mainly on the RAM." Now, as Captain Freemantle's essay received the prize, and as he exhibits the utmost familiarity with the Signal Book and the Manual of Drill, for neither of which he seems to entertain much respect, we may assume that he fairly represents the state of naval tactics in the English Navy of to-day, and that, to use his own language, they are still "groping in the dark."

It is plain there is little to be hoped for there. The French Navy is pretty much in the same category. Where, then, shall we look for light but to ourselves?

The position of our Military Instructor, it is hardly necessary to explain, is one of extreme delicacy. Entering upon an entirely novel undertaking, and thrown, I will not say among strangers, but among officers of another profession, it were singular, indeed, did he find himself wholly free from embarrassment.

Lieutenant Tasker H. Bliss, 1st Artillery, U. S. Army, an officer who stands deservedly high in his own profession, has kindly consented to give us his time and his best endeavors to render his department of this Institution worthy of the profession he represents. He fully understands the theory on which our studies are to be conducted. He is not here to teach us *our* profession, as has been vainly imagined. Knowing little of our profession, he is here to teach us what he knows of *his own* profession. Let us co-operate with him, then, and by our attention and application attain such good results as to prove that comparative tactics is the true scientific method of studying naval warfare under steam.

We cannot close this paper without one or two allusions to the lessons of history which seem most pertinent to our subject. It has often been observed that the ancient Greeks are our masters in the art of war. The Greeks were so convinced of the necessity of the study of theory, and of the insufficiency of practice alone, that they instituted public schools where they taught upon fixed principles and rules the science of war. The Spartans, we are told, were the first who formed their tactics into a regular system, to be taught as a part of education. Other nations imitated the Greeks. Princes and states maintained, at their own expense, either military academies or skillful professors of tactics for instructing in the theory those young men who devoted themselves to the profession of arms.

The Greeks reduced the whole of the science to calculation and rule. This precision carried the military art among them at once to a high degree of perfection. "The Greeks," observes one military writer, "although they made their tactics the basis of the science of war according to examples given by their masters in the schools, nevertheless considered this as composing but a small proportion of the acquirements necessary to a general. The art of commanding an army was justly considered as a most important part of knowledge, and was taught accordingly. This embraced all the grand objects connected with war."

The story has often been repeated of Hannibal having ridiculed one of those professors of tactics who, with pencil and tablet in hand, had the assurance to debate with him upon the operations of war. ("The Military Mentor," Salem, 1808.) But the wisdom of the Greeks in establishing a regular system of military instruction rests upon too solid a foundation to be shaken by any such anecdote. Besides, Hannibal himself had enjoyed unusual advantages in respect to mili-

tary education. He was early trained in arms under the eye of his father, Hamilcar, and probably accompanied him in most of his campaigns in Spain. He was certainly with him in the battle against the Vettones, in which Hamilcar perished, Hannibal being at that time but 18 years of age.

We do not find in history any mention made of naval schools among the ancients, but there is every reason for believing that the large fleets of galleys common to ancient Greece and Rome were fought by military men according to the military tactics of the times. The rules of the art of war, as then understood, comprehended both the land and the sea forces.

Here, then, is the philosophy of history teaching us by great examples. Inspired by the example of the warlike Greeks, and knowing ourselves to be on the road that leads to the establishment of the science of naval warfare under steam, let us confidently look for that master mind who will lay the foundations of that science, and do for it what Jomini has done for the military science.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE FIRING OF HIGH EXPLOSIVES FROM GREAT GUNS.

By Commander Albert S. Barker, U. S. N.

As the subject of firing high-explosive shells from great guns is engaging the attention of many at the present time, I have thought it well to follow the advice of my friend Professor Munroe, who has himself published so many valuable "Notes on the Literature of Explosives," and to place on record a correct history of the first successful attempts ever made in the United States (so far as known) to fire dynamite in shells from great guns, together with my views on the subject as officially expressed at intervals during the last twelve years.

These experiments prove, so far as a limited number can be relied on to prove anything:

1st. That dynamite can be safely fired from great guns in shells without extra precautions being taken to reduce the shock of discharge.

2d. That the ordinary Bormann fuse will explode dynamite shells.

3d. That howitzers or guns of small calibre can be employed to throw cases of dynamite or gun-cotton against vessels regardless of the ordinary devices used to protect ships from torpedo attacks.

One of the chief sources of apprehension in the use of high explosives for charging projectiles arose from the fact that it was believed that the highly sensitive fulminate-of-mercury fuse was necessary for its complete explosion.

On the 18th of May, 1874, while at the Torpedo Station, certain experiments—made, I am quite sure, at the suggestion of Professor Farmer—seemed to prove that a simple gunpowder fuse would detonate nitroglycerine and dynamite if either the gunpowder or the high explosive were confined in a strong metallic case. The following are the experiments referred to:

1st. Some yarns were soaked in nitroglycerine, and the platinum wire of an ordinary station fuse connected to a Farmer machine was laid on them. The wire was melted and the yarns were set on fire, but the nitroglycerine did not explode.

2d. The platinum wire of a fuse was put into nitroglycerine. The wire was melted, but the nitroglycerine neither burned nor exploded.

3d. Same as No. 2, except that the wire was longer. The nitroglycerine neither burned nor exploded.

4th. Two pieces of No. 36 platinum wire two inches in length were placed in a dish containing nitroglycerine. The wire was melted as usual by the use of the Farmer machine, but the nitroglycerine was neither set on fire nor exploded.

5th. One inch of platinum wire was laid on some yarns saturated with nitroglycerine. The wire was melted and the yarns were set on fire, but there was no explosion.

6th. One and a half ounces of nitroglycerine were placed in an iron tube, and a Stowell metal fuse of rifle powder was used. The nitroglycerine *detonated.*

7th. One and a half ounces of nitroglycerine were put in a tin tube, and an ordinary station fuse of rifle powder, in a wood case, was used. The nitroglycerine *detonated.*

8th and 9th. Same fuse, with same amount of nitroglycerine in a *paper* case, was used. There was no explosion of the nitroglycerine.

10th. Same fuse, same amount of nitroglycerine in a *tin* case, was used. Nitroglycerine *detonated.*

11th. A copper-case fuse with mealed powder and same amount of nitroglycerine in a *paper* case was used. *Detonated.*

12th. A copper-case fuse with mealed powder and same amount of *dynamite* in a *paper* case was used. *Detonated.*

The following note was made at the time of the foregoing experiments: "From these experiments it would seem that nitroglycerine can be detonated by gunpowder if either the fuse case or the case holding the nitroglycerine is made of some metal and very strong. Thus it seems as if we could do away with the fulminate fuse, which is rather dangerous to make."

The result of these experiments gave a new impulse to a desire which I had long entertained of ascertaining whether or not shells filled with dynamite could be safely fired from great guns. Accordingly, on the 9th of June, 1874, I submitted to Captain (now Rear-Admiral) Edward Simpson, U. S. Navy, who commanded the

station, a list of experiments which I desired to make in order to ascertain the following facts: 1. Will the shock of a fulminate fuse detonate nitroglycerine, the latter being placed in an inner tube and the fuse between the inner and outer tube, both tubes being of iron? 2. Will a gunpowder instead of a fulminate fuse produce the same effect? 3. Will the shock transmitted through the metal case containing the nitroglycerine have any effect on the explosive, the tubes being arranged as before, but the one containing the explosive being of copper or tin? 4. Will the effect be the same when dynamite is substituted for nitroglycerine?

Should these experiments warrant me in so doing, then I desired to make the following experiments: 1. To fire from a musket or rifle a brass tube or metallic case filled with dynamite. 2. To put nitroglycerine or dynamite in an ordinary shell and explode it with an ordinary time fuse. Should this *not* explode the charge, (3) to try the same kind of fuse with an extra quantity of powder placed in the shell near the fuse. If this should detonate the charge in the shell, (4) to fire a shell filled with dynamite from a howitzer, firing it against a rock, if possible, so that, should the shock of the discharge fail to detonate the dynamite in the shell, it could be seen if the impact of the shell against the rock would do it. 5. To fire an ordinary shell filled with dynamite and fitted with ordinary service fuse. And (6) to try the same with percussion fuse. Captain Simpson took upon himself the responsibility and cheerfully granted the request.

I must here mention that Professor Hill, the expert on explosives, who was absent from the station on the 18th of May, while possibly willing to admit, in view of what had been done, that gunpowder fuses might at times detonate dynamite and nitroglycerine, insisted that they could not be relied on to do so at all times and under all circumstances. His opinion proved to be correct, as shown some months later, when it was attempted to detonate *unconfined* dynamite with a gunpowder fuse.

The following are the experiments as conducted, the fuses used being exploded by means of electricity, using the Farmer machine:—

EFFECT OF A FULMINATE-OF-MERCURY FUSE (20 GRAINS) ON NITROGLYCERINE IN A METALLIC TUBE PLACED INSIDE ANOTHER TUBE WITH FUSE BETWEEN.

June 15, 1874. No. 1. Inner tube made of one-inch iron gas pipe containing one ounce of nitroglycerine. Pipe plugged with

wood at one end. Outer tube of good iron, half inch in thickness. Fulminate-of-mercury fuse between. Top of inner tube not plugged. *Detonated*, throwing the whole mass a long distance into the water, and breaking the small rock on which the tubes were placed.

No. 2. Outer tube of one-inch iron gas pipe. Inner tube of brass one-sixteenth inch thick; length, one and a half inches; diameter over all, half inch, containing quarter ounce nitroglycerine. Fulminate-of-mercury fuse between. *Detonated.*

No. 3. To see the effect of an unconfined fulminate fuse on the metal of a tube. In a brass tube one-sixteenth inch thick, three inches long, three-quarters inch diameter, open at both ends, placed a fulminate-of-mercury fuse. Exploded, tearing the tube, although there was considerable space around the fuse and at the ends of the tube for the escape of gases.

No. 4. Same as No. 2, with same effect.

EFFECT OF GUNPOWDER FUSES.

June 16th. No. 5. In an ordinary iron gas-pipe tube, plugged tightly at one end, placed a small brass tube containing quarter ounce dynamite. Fired with mealed powder fuse, metallic case, which was jammed in between the two tubes. The fuse alone exploded, blowing out the inner tube.

No. 6. In a large iron tube, plugged at one end, placed a large brass tube one-eighth inch thick, six inches long, one and a half inches diameter, containing one ounce of dynamite. Cap screwed on one end and the other end soldered. Fuse of mealed powder, metallic case, jammed between the two tubes. Fuse alone exploded, forcing out the rear plug of the large outer tube about one inch.

No. 7. Used same large iron tube, inside of which placed a large brass tube, as before, containing one ounce of dynamite. Used DE_3 igniter (rifle powder and wood case) and filled outer tube with sand. Fuse alone exploded, throwing out the sand.

No. 8. In a brass tube three inches long, three-quarters inch diameter, put a half ounce of dynamite. Plug the ends and put this in the large iron tube. Put in DE_3 igniter and a charge of powder half as great as is contained in a DE_4 fuse, or from three to four charges for an ordinary musket. The igniter was placed between the tubes and the powder poured about it, while the remaining space was filled with sand. Exploded, driving out the rear plug and the sand, leaving the tube of dynamite uninjured inside.

No. 9. Used same inner tube, placed in an iron tube of ordinary one-inch gas pipe; space so small that with the insulated leading wires in the iron tube the inner one had to be forced down. Placed the same amount of powder as before in the outer tube at the base of the tube containing the dynamite. Fuse of mealed powder, metallic case. Fired at a rock a few feet distant. The end of the outer tube was torn, but the rock showed signs of having been struck. An end piece of the brass tube was picked up. The sound of the explosion was loud, but I could not tell whether the dynamite detonated or not: it certainly did not while in the iron tube, as the tube was not torn where the dynamite had been, but only where I had placed the large charge of powder. No sign of a great disturbance was discovered; still, judging from the result of the next experiment, it is possible that the dynamite may have detonated after having hit the rock, as a plug was protruding nearly three-quarters of an inch from the tube.

No. 10. Used same sized brass tube containing half ounce of dynamite. Put this in an iron gas-pipe tube six inches long and one inch in diameter. Used an ordinary charge of rifle powder and a DE₃ igniter. A wooden plug projected from a brass tube a good half inch. A board was placed four feet in front. Iron tube plugged at rear end. When fired much of the gas of the powder escaped at the rear, driving out the plug. The tube of dynamite entered the target one-fourth of an inch, and when picked up *was very hot*, with the hard oak plug driven entirely into the tube, a little counter-sunk, and *nitroglycerine was boiling out through the pores of the plug*. As the force exerted by the powder on the brass tube was not so great in this case as in No. 9, and as the target was a rock in the former case, I am inclined to the belief that the heat generated by impact may have detonated the mass in the preceding case (No. 9).

These experiments showed the necessity of having some kind of a gun, and of doing away with rough tubes and wooden plugs. Accordingly, a gun was made of wrought iron, calibre .75 inch, depth of bore 12 inches, thickness of barrel half inch; the whole firmly bolted to a block of wood. From this I fired projectiles consisting of brass tubes one-sixteenth inch thick, one and three-quarters inches long, and five-eighths inch in diameter. They contained a quarter ounce of dynamite.

June 18th. No. 11. Used small charge of rifle powder. Placed an inch board for a target at a distance of six feet. Tube passed through the board into the water.

No. 12. Same as No. 11, but with the ordinary charge of powder for a musket. Tube passed through the board and struck a rock in rear of the target. Picked up a piece of the tube. No detonation observed.

No. 13. Same as No 12, but with an increased charge of rifle powder. Target was blown down just before firing. Projectile went into the water. No detonation. Gun recoiled several feet.

No. 14. Charge of powder at least three times as great as for ordinary rifle. Tube went through the target and hit a rock, breaking off a small piece, then glanced into the water. Gun recoiled several feet.

June 19th. No. 15. Ordinary charge of powder. Fired at a rock. Tube much battered. No detonation.

No. 16. Ordinary charge of powder. Fired into a mud-bank three feet distant. Tube recovered in perfect shape, except that the soldered end came off.

No. 17. Double charge of powder. Target two and a half feet distant, set against a mud-bank. Projectile passed through the target, going into the mud-bank several inches. Found the tube torn, but the dynamite was picked up with the tube. Gun recoiled seven feet.

No. 18. Double charge of powder, tube of copper, containing one-eighth ounce dynamite. The tube passed through a board, struck a rock in the rear, then doubtless glanced into the water, as it could not be found.

No. 19. Same as No. 18. Fired through the target into the bank.

Experiments with 24-Pounder Shells at Rest.

These were exploded in the bomb-proofs on Rose Island.

June 22d. No. 20. Put four and a half ounces of dynamite into a 24-pounder shell. Used ordinary Bormann fuse, with an additional brass magazine containing a small rifle charge of powder. Placed in bomb-proof on Rose Island where there was much rubbish. Detonated, tearing the shell into many fragments, twenty-seven of which were picked up from the rubbish. Made a large hole in the ground.

June 25th. No. 21. In another bomb-proof, where there was not so much rubbish, exploded between three and four ounces of dynamite in a 24-pounder shell placed on a wrought-iron slab 4 feet by 5 inches by 1 inch. Used a small additional magazine of powder. Picked up fifty-eight pieces of shell and counted forty-nine marks on

the walls of the bomb-proof. The iron slab was somewhat bent, and the brick and stone under it were crumbled. A piece of the masonry running up the bomb-proof and projecting out eight inches, one foot in width, distant one and a half feet from the shell, was cut out a foot in depth.

No. 22. Put four ounces of dynamite in a 24-pounder shell, Bormann fuse, with no additional charge. Placed shell on same iron slab three inches from the wall. Detonated, bending slab. Tore quite a large hole in the solid masonry to a depth of six inches. Picked up seventy-nine pieces of shell.

No. 23. Put four ounces of dynamite in a 24-pounder shell, which was laid on fourteen bricks placed one on the other. Shell rested against an iron slab, which was itself against the wall, bringing the shell three feet from the ground. There being no fuse at hand for this shell, a small brass magazine was used. Slab was considerably bent by the explosion. The stone in the masonry against which the slab rested showed marks of having been shattered, but no large pieces came out. All the bricks underneath were broken into fragments. Fifty-six pieces of shell were picked up.

No. 24. Put three and a half ounces of dynamite in a 24-pounder shell, Bormann fuse only. Placed shell as in No. 23. Broke all the bricks upon which it rested. Bent slab, throwing it quite a distance, and jarred the masonry against which it was placed.

No. 25. Put three and a half ounces of dynamite in a 24-pounder shell, Bormann fuse only. Shell placed on a slab of iron, which was laid on the ground. Detonated with same effect as usual.

No. 26. Put what was left of the dynamite which I had taken to the island, about two ounces, in a 24-pounder shell, and used an old Bormann fuse the chamber of which had been cut into. The fuse alone went off. Probably part of the powder had shaken out of the chamber of the fuse, as it was a very old one and had been cut a long time. This and the very small quantity of dynamite in the shell—leaving so much room—were the causes, doubtless, of failure.

No. 27. In the same shell screwed a small brass magazine of powder. It *now* detonated, and threw the iron slab, weighing 80 pounds, which had been placed against the shell, thirteen feet and shattered corner of bomb-proof to some extent.

Experiments at Firing Dynamite Shells from a 24-Pound Howitzer.

June 30. A 24-pounder howitzer was transported from this station to Rose Island and mounted in one of the bomb-proofs. The cartridges used were the ordinary service charges, and the gun was fired in every respect as it would have been in service, except that the vent was filled with powder, which was ignited by electricity. *No measures were taken to reduce the shock of the discharge on the projectile in any of these trials.*

No. 28. From a 24-pounder, fired a shell nearly full of dynamite into a thick wall thirteen feet distant. The shell exploded on impact, making a hole in a solid rock seven inches in depth, which spread out considerably. The rock was pulverized. Picked up seventy-five pieces of shell.

July 2d. No. 29. Filled a 24-pounder shell loosely with dynamite and fired it into the wall of bomb-proof about forty feet distant. Detonated on impact, scooping out a hole in the brick, stone and mortar to the depth of ten inches.

No. 30. Then, to compare this effect with that of an empty shell, fired an empty 24-pounder shell into the wall at same distance. Penetrated fourteen and a half inches into wall, making a round hole instead of a spreading one. The shell broke, but half of it was taken out in one piece.

No. 31. Fired at same distance a 24-pounder shell loosely filled with dynamite. Detonated on impact, making a spreading hole like the first (No. 28), and penetrating about the same distance.

The following note was made at the time: "It seems from these (experiments) that dynamite detonates at the instant of impact, and so instantly that the shell does not penetrate as far as it would if it had no charge in it; but the shattering effect is greater."

Firing up the Bay.

July 8, 1874. Fired a 24-pounder shell filled with dynamite from bomb-proof on Rose Island. Pointed the gun up the Bay. Did not cut the fuse. The shell did not explode, but struck the water a mile distant (estimated).

No. 33. Fired a 24-pounder shell filled with dynamite, using Bormann fuse cut at four seconds. A half gale of wind was blowing in the direction of the flight of the shell. It was also cloudy. Several

disturbances were noticed in the water just beyond the island, probably pieces of sabot. The smoke attending the bursting of the Bormann fuse was so slight in amount it was not seen, owing to the peculiar state of the weather. The sound of the projectile through the air was heard for some time, as usual. Small pieces of shell striking the water in such a rough sea could not be seen at a great distance.

July 9th. No. 34. Fired a 24-pounder shell filled with dynamite, fuse purposely left uncut. Gun given almost extreme elevation. The shell went a long distance up the Bay and struck the water without exploding. Sea perfectly smooth ; no wind.

July 15th. No. 35. Put fourteen ounces of dynamite in a 24-pounder shell and fired it up the Bay. The Bormann fuse had been in the shell several days, and, though cut at four seconds, it did not burn. I had added a small magazine of powder, which did not ignite. The shell struck the water a long distance up the Bay without exploding.

No. 36. Put fourteen ounces of dynamite in a 24-pounder shell, Bormann fuse, with a very little extra powder, to show more clearly when the shell should burst. Fuse cut at four seconds. Shell burst at proper time.

No. 37. Put fourteen ounces of dynamite in a 24-pounder shell. Used Bormann fuse only, which was cut at three and a half seconds. Shell exploded at the proper time, scattering pieces to the right and left for a great distance. Not a grain of powder to help the fuse. The fuse made very little smoke.

Brief Recapitulation.

The first two and the fourth experiments were made to see what effect the shock of a fulminate-of-mercury fuse would have on nitroglycerine when separated from it by a diaphragm of metal. It was found that the fulminate fuse containing twenty grains would tear through the metal employed, hence all further experiments with the fulminate fuse ceased. The next series of experiments showed that in no case did the shock of a powder fuse, whether with a metallic or wooden case, detonate nitroglycerine when it was separated from the fuse by a metal diaphragm.

Again, in no case was there a premature explosion in all the experiments with the wrought-iron gun, although the best rifle powder was used with varying charges.

Again, in all the experiments made with the shells at rest, it was shown that the dynamite contained in them was exploded by the use of a gunpowder fuse, with or without an additional priming of powder, and the force of the explosions seemed to me to be much greater than it would have been had the shells been filled with powder instead of dynamite. I am sorry, however, that I did not explode one filled with powder, in order that the different effects of the explosions might have been compared at the time.

Again, the result of the howitzer experiments in firing shells charged with dynamite was very satisfactory. There were no premature explosions. Some of the fuses were left uncut on purpose, in order to observe the extreme flight of the shell. One shell was not seen to burst, neither was it seen to strike the water, but this is easily accounted for from the fact that dynamite makes little or no smoke when it detonates, and at the time referred to a half gale of wind was blowing, clouds obscured the sky, and the water was very rough. The flight of the shell was heard for a short time after it left the gun.

Having exhausted the available stock of shells at the Torpedo Station, experiments ceased, and on the very day of firing the last shell my detachment was received at the station. In a personal interview with the Chief of the Bureau of Ordnance soon after this, I urged that the experiments be continued on a larger scale, and asked that he would, at least, have a XV-inch shell filled with dynamite hung against an iron target and exploded. He gave some encouragement that this would be done, and a month later the late Commander Marvin, U. S. N., at that time, I think, in charge of the experimental battery, told me that it was to be done; but doubtless other things interfered.

These experiments were made in 1874. I then thought that this question was, perhaps, the most important one connected with ordnance; for we were far behind other nations in respect to ships and great guns, and should it have proved practicable to fire dynamite shells, our smooth-bore guns of large calibre could have been used, and at a bound we would have nearly regained our old position of superiority; for the armor of vessels was not so thick then as now, great guns were not so powerful, and machine guns had not reached their present state of development; but nothing further was done. Four years passed, and in 1878 I was again at the Torpedo Station, Captain K. R. Breese, U. S. Navy, commanding. Finding that my former experiments could not be continued, I requested permission to

pursue another branch of the subject, and addressed a communication to Captain Breese as follows:

TORPEDO STATION, NEWPORT, R. I., *June* 29, 1878.

Sir:—Can cases filled with nitroglycerine, dynamite, or gun-cotton be fired from great guns in safety to the guns and to those operating them? If either of them can be used in this manner, it seems to me the whole subject of torpedo warfare is immensely simplified.

To my mind the solution of this question is of more importance than that of any other connected with the subject of torpedoes. Four years ago I carried on a series of experiments at this station which, so far as they went, demonstrated that shell filled with dynamite—at least such dynamite as was then provided—could be fired from guns. My experiments were limited to the 24-pounder howitzer. The Chief of the Bureau of Ordnance did not see fit to encourage further experiments in that direction, and there the matter ended. That dynamite (or similar mixture) is regarded as comparatively harmless, is shown from the fact that it is transported by rail all over the country, and is used extensively in mining, etc. If the Whitehead and Harvey torpedoes are intended to be charged with gun-cotton or dynamite, these explosives will have to be carried in the ships from which these torpedoes are manipulated; hence, the objection cannot be raised by advocates of the Whitehead and Harvey that the danger of using these explosives on board ship is too great.

I now propose a plan which, if practicable, will enable us to use dynamite, nitroglycerine, or gun-cotton from the ordinary ship's launch, and I therefore respectfully request that I may make a few preliminary experiments with a 24-pounder howitzer.

I wish to see if I cannot throw a weight of from fifty to one hundred pounds a hundred feet or more without undue strain to the gun. If this can be done, I think torpedoes may be fired or projected against a vessel from an ordinary launch, and thus the difficulty of reaching a vessel protected by nettings, booms and other obstructions will be overcome. Not only this, but the launch could run at full speed past the broadside of the vessel and be out of harm's way by the time the torpedo exploded, for the gun could be trained broad off the bow, or even well-nigh abeam, when fired. I grant that the explosions might not always be at or below the water line, but let fifty pounds of dynamite explode against the vessel at night, it could not fail of demoralizing the crew, and a second attempt could be made before order was restored. I enclose with this a summary of my experiments made with dynamite, referred to above.

Very respectfully, etc., etc.

Captain Breese thought well of the idea and granted the request, although it interfered somewhat with the regular work at the station. And so soon as I had satisfied myself of the practicability of the scheme by actual practice, I reported it, in order that, should the Bureau of Ordnance see fit, the experiments could be carried on with the Bureau's approval and with greater facilities. At the suggestion

of Captain Breese I addressed the Bureau on the subject, and as an account of the experiments is contained in the letter, a copy is here inserted:

TORPEDO STATION, NEWPORT, R. I., *August* 8, 1878.

Commodore WM. JEFFERS,

Chief of Bureau of Ordnance, Washington, D. C.

Sir:—At the suggestion of Captain Breese, commanding this station, I beg to submit the following on the subject of torpedoes:

In July, 1874, I submitted to Commodore (then Captain) Simpson a report of some experiments made by me, in which from a 24-pounder howitzer I fired shells filled with dynamite. These experiments were undertaken to demonstrate that it would be safe to fire large shells or cases of dynamite, so that (I quote from the report) "wherever a large gun could be mounted, *there* would be a place from which torpedoes—for so we might call them—could be launched with great accuracy against an enemy, and much expense saved the Government by rendering unnecessary greatly extended fortifications and expensive torpedoes such as the 'Lay,' 'Whitehead,'" etc. This report was forwarded to the Bureau of Ordnance.

As there was no gun larger than a 24-pounder howitzer at the station, my experiments ceased after having fired successfully about a dozen shell. Last month, permission to make experiments of a somewhat similar character was kindly granted me. I wished to see if 12-pounder or 24-pounder howitzers could not be used to throw large charges of dynamite against vessels distant 50 to 200 yards, which charges should explode upon impact by means of percussion fuses. If this could be done, it would render useless as a defense against torpedoes of this class such obstructions as are now placed around vessels to protect them from the attack of torpedoes, for launches mounting one or more guns could run at full speed just outside the obstructions, and when abreast, or anywhere within 200 yards, these cases of dynamite or gun-cotton could be fired in quick succession without slowing the engines, or getting so near as to become entangled in the obstructions. To this end I made the following experiments:

July 12th. Made a soft-wood shaft to fit the bore of a 12-pounder. The shaft was grooved to within four inches of the inner end. It projected a few inches from the muzzle. On the outer end was secured an empty 24-pounder shell. The whole weight of the projectile was 30½ pounds. The charge of powder used was ½ pound cannon mixed with enough rice to preserve the original size and shape of the cartridge for the 12-pounder. Another reason for mixing rice with the powder was to make it burn more slowly. This projectile was sent as straight as an arrow to a distance of 450 feet.

SECOND EXPERIMENT.

July 15th. A new pine shaft was fitted to the bore as before, the inner end shod with iron $\frac{1}{16}$ inch in thickness. Secured an empty 32-pounder shell to the outer end. Total weight 43 pounds. Charge of powder the same as before (½ cannon mixed with rice). This projectile made a perfect line shot, being thrown from 100 to 150 yards.

THIRD EXPERIMENT.

Same as above with same result.

FOURTH EXPERIMENT.

Fitted a shaft to a 24-pounder similar to the shaft used above. On the outer end an old cast-iron torpedo case filled with 41½ pounds of rice was secured. Whole weight of projectile, 99½ pounds. Extreme elevation on boat carriage. Much of the gas escaped on account of the imperfect construction of the shaft; nevertheless, this projectile was sent 50 yards, making a perfect line shot. Charge of powder used was one pound, mixed as before with rice.

These experiments, crude as they were, satisfied me that there would be no difficulty in throwing from 25 to 100 pounds of dynamite from 50 to 200 yards, using simply the ordinary boat howitzers.

There is much room for experiment to determine the best kind of powder to be used for this purpose, the proper charge, and the best kind of shaft, as well as the best form of case in which to place the explosive. There is no doubt but that the case should be made of steel.

In order to see what effect a charge of dynamite would have on a ship's side if exploded against it, the commandant of the station had a wrought-iron slab four and a half inches thick, three and a half feet wide and six and three-quarters feet long placed in position, and a cylindrical case containing 40 pounds of dynamite was placed against the centre of the slab.

The slab was bent by the effect of the explosion . . . . making a clear cut in the back of the slab to the depth of four inches, extending the whole width of the slab. The lumber placed in rear of the slab to support it was badly broken. My own impression is that for general use in steam launches, cases of 50 pounds of dynamite would be sufficiently great to give satisfactory results. The cylindrical case used in this experiment could have entered the bore of an VIII-inch gun. I believe that if a slow-burning powder were used, cases of dynamite could be fired a mile with great accuracy from great guns, the projectile being *set home against the cartridge* and thrown as a shell. In other words, the use of the wood shaft might be dispensed with when firing from great guns. It would be interesting to know what the effect of 50 pounds of dynamite would be if exploded on the deck of an ironclad. I respectfully submit the above to the Bureau, believing it to be a matter of the greatest importance, for it seems to me that torpedoes of this character, defying obstructions placed around vessels, might in the vast majority of cases be advantageously substituted for the awkward "spar," the cumbersome "Harvey" and the expensive "Lay," "Ericsson," and "Whitehead" torpedoes in offensive warfare. I have the honor to be, etc., etc., etc.

This communication was returned to the Torpedo Station with the following endorsement:

15th August, 1878.

Respectfully returned to the Torpedo Station. The Bureau has carefully perused the communication of the 8th inst. from Comdr. A. S. Barker. The

Navy is not prepared at present to carry dynamite to sea, and hitherto all experiments in firing dynamite shells from guns have been unsuccessful and useless. Upon a practically large scale, with projectiles carrying from 30 to 50 pounds, no useful results could be expected. Our funds will not admit at present of any such course of experiments. (Signed) W. N. JEFFERS,

Com. and Chief of Bureau.

Another four years pass, when I again have an opportunity to refer to the subject officially, in a communication to the Hon. Secretary of the Navy, dated Nov. 27, 1882, in obedience to an order to make a report upon the monitor Montauk, which I had commanded, and to offer suggestions for improvements. After having suggested a few changes—among others, that the guns be given an elevation of at least twelve degrees, by putting in improved gun-carriages, etc.—I continued substantially as follows:

In this connection I respectfully submit what I consider to be the most important change of all, and one which warrants careful attention—viz.: that in place of, or rather in addition to, the ordinary shell, there should be furnished projectiles of a peculiar kind filled with a violent explosive. They might be termed "torpedo shells," a name already used to designate certain projectiles thrown from Krupp's mortars. They should be made of steel, and for a XV-inch gun should have a capacity for at least 100 pounds of explosive.

Eight years ago, while at the Torpedo Station, with the approval of Commodore Simpson, commanding the station, I fired from a 24-pounder howitzer several shells filled with dynamite. The experiments, though limited in number, were successful, but the Chief of Bureau of Ordnance at that time did not think it advisable to have them continued on a larger scale.

Since that date Nobel's gelatine has been added to the list of explosives, and, from reports, it is admirably adapted for use in this manner. A XV-inch gun could throw a shell containing 100 pounds of gelatine a distance of two miles. Should the shell strike the solid armor of an ironclad, the explosive would probably detonate, but, whether it would or not, it would be easy to fit percussion and time fuses. Were the "monitors" thus supplied, foreign ships would scarcely care to venture within range of our guns, and beyond that range, provided an elevation of 12° could be obtained, they might fire at our turrets all day without making a satisfactory hit. The cross-section of these turrets is less than 25 feet by 12 feet, or but little larger than an ordinary target.

It is estimated by some English authorities that not more than one shot out of fifty hits a target in ordinary target practice at sea, and the usual distance of a target from a ship is much less than two miles. If, then, but one shot in fifty should hit the turret, the chances are that three-fourths of those hits would be glancing blows, owing to the curved surface of the turrets. All experience proves how difficult it is to hit a small object at sea when more than a mile distant. A few experiments, at comparatively small expense, would determine the practicability of using such shell, and also show the effect they would have against iron targets.

I am as thoroughly convinced that these projectiles will be used as I am that there will be future wars; it is only a question of time. Already Krupp is dropping "torpedo shells" from his light mortars with great accuracy and effect, but in actual war they will be filled with gelatine or other explosive instead of powder. Why should not the United States be the first to make the change, if it prove practicable, and utilize her big smooth-bore guns? It would not only greatly increase the efficiency of the "monitors," but also add to the importance of our coast fortifications.

That these were efficient vessels during the late war, hundreds of shot marks on turret and hull attest, and should the suggestions contained herein be adopted, I doubt not they will again be made efficient and formidable, and will be invaluable for the protection of our harbors against attacks by foreign navies.

I am, Sir, etc., etc., etc.

Thus for twelve years, or since making the experiments in 1874, I have many times privately, and several times officially, referred to them and urged the importance of the subject.

I have frequently in this paper used the word "detonated" when referring to the explosion of dynamite and nitroglycerine. It has been questioned of late whether the effect of dynamite, if exploded with a gunpowder fuse, is ever as great as when a fulminate-of-mercury fuse is used—in other words, whether complete detonation actually takes place. It is further questioned whether dynamite or gun-cotton shells, bursting alongside an armored vessel, would materially injure her.

Doubtless the first question will soon be definitely settled by experiments at the Torpedo Station, and if it shall be proved that dynamite and gun-cotton shells will not be effective when exploded *alongside* an armored vessel, they must necessarily be effective when dropped *on* her decks from mortars. I myself am inclined to believe that the moral effect of high-explosive shells will always be great, and that they will also have a material effect on the vessel when exploded alongside.

My prediction in regard to the use of these shells is already being fulfilled, if the reports are true which come to us from abroad, and I am glad that our own Government is taking a deep interest in the subject. Congress has appropriated, or, it is said, will appropriate $350,000 for the construction of a pneumatic dynamite gun-vessel which shall carry guns guaranteed to throw projectiles containing one hundred pounds of dynamite, *or other high explosive*, a distance of at least one mile. Dare any one assert positively that our XV-inch guns cannot do even better than that?

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

COMPRESSED GUN-COTTON FOR MILITARY PURPOSES, PARTICULARLY REGARDING ITS USE IN SHELL.

Experiments Made and Described by Max von Förster, First Lieutenant (Retired), Superintendent of the Gun-Cotton Factory of Wolff & Co., Walsrode, Germany.

TRANSLATED BY LIEUTENANT KARL ROHRER, U. S. N.

INTRODUCTION.

We have, in continuation of previously published researches, experimented further with compressed gun-cotton as to its development of strength, using greater quantities of the explosive and noting the effect of confinement thereon.

We have endeavored to carry on the experiments under circumstances such as would present themselves in military practice. With reference to military use of compressed gun-cotton, we have considered the advisability of paraffining it, also of coating by dipping it into a solvent solution of acetic ether. Finally, we made numerous experiments with gun-cotton-charged shell as to their explosive effect, and facility of firing them from existing ordnance, considering especially the adaptability of granulated gun-cotton for charging the same.

In the recently published work of Lieutenant-General Brialmont, "La Fortification du Temps Présent," Bruxelles, 1885, he refers particularly to the important effects of gun-cotton-charged shell, describing fully one charged with gun-cotton discs. This has encouraged us to hope that an account of our experiments may be of interest.

The experiments with gun-cotton shell made by us during several years past have been made entirely at our own expense and volition,

with the exception of those made by the artillery authorities of a foreign power with steel gun-cotton shell six calibres in length, in the presence of the author.

A portion of the results of our experiments has been made generally known through the following-named imperial German patents granted to us in common with Mr. W. F. Wolff:

No. 22,418.—Method of exploding wet compressed gun-cotton under water. September 1, 1882.

No. 24,674.—Explosive projectile charged with pressed gun-cotton. January 14, 1883. Treating of a shell with unscrewing head, filled with gun-cotton in disc form, provided with a detonator which is independent of the fuse and is located more toward the base of the shell.

No. 26,014.—Method of wholly or partially coating compressed gun-cotton, nitrated wood and other cellulose by means of treating same with a solvent solution. March 9, 1883.

No. 33,867.—Method of filling hollow projectiles with compressed granulated explosive material. May 2, 1885.

Our experiments, so far as regards the nature of the objects destroyed, could only be carried on within the confines of a gun-cotton factory, yet it is believed they will afford a standard of comparison for objects of all kinds.

We can, however, call attention to the explosive effects of compressed gun-cotton in submarine work by recounting the destruction of sunken vessels and wrecks accomplished by us for the Imperial Admiralty, the Imperial Navigation Bureau at Wilhelmshafen, other public authorities, and for private persons.

In our experiments we have used exclusively the gun-cotton manufactured at the powder and gun-cotton factory of Messrs. Wolff & Co., Walsrode. This gun-cotton is in use in the German Army, has also been tested and accepted for the German Navy, a large quantity having been taken into store. It is supplied to many armies and navies in and beyond Europe. So it may be said to fulfil all the conditions of a first-class article of gun-cotton, and therefore we may consider the results attained with it as equivalent to those to be attained by any good gun-cotton. If not otherwise stated, the specific gravity of this gun-cotton is 1.1, and it has an average of 12.6 per cent. of nitrogen by weight, in the absolutely dry gun-cotton and included foreign matter.

It is known that wet gun-cotton can be detonated by means of a

proportionate weight of dry gun-cotton, and we have so detonated it, whether special mention of the fact is made or not.

We detonated the dry gun-cotton by means of 1 gram fulminate-of-mercury detonators obtained from the Linden Primer Factory, Egestorf, Linden, near Hanover. These detonators retain their strength after a storage of five years, as we have so far found by experience.

Experiments with Regard to the Development of the Power of Compressed Gun-Cotton.

A.—*Unconfined Dry and Wet Gun-Cotton Placed upon Leaden Cylinders and Detonated.*

Experiments 1–4.—360 g. gun-cotton detonated upon a leaden cylinder 46 mm. diameter by 100 mm. high destroyed it; the dry gun-cotton half destroyed it, while the wet destroyed it entirely.

Experiment 5*a*.—6500 g. dry gun-cotton in discs 14 cm. diameter and a total height of 43 cm.

Experiment 5*b*.—6500 g. gun-cotton of same shape and dimensions and same dry weight, but with 25 per cent. of moisture.

In these two cases the gun-cotton was placed upon two blocks of rolled lead, each 15 cbcm. in volume, one above the other, and the two upon a perforated iron plate. The dry gun-cotton destroyed the upper leaden block, while the wet destroyed both.

Experiment 6.—A disc of dry gun-cotton 14 cm. diameter and 6 cm. high, weighing 920 g., provided with a detonator, was placed upon two leaden blocks as used in 5*a*, 5*b*, destroying them to about the same extent. It thus appears that an explosive charge of gun-cotton of 920 g. acts as powerfully on the object immediately under it as one of 6500 g., when the surfaces of the charges in contact with the object are equal. It may be that the detonator exercised an important influence in the development of the explosive force in this experiment; said influence will be more closely examined later.

In the continued experiments, the weight of the gun-cotton was so far reduced that the object upon which it was to develop its strength was not entirely destroyed; yet it was sufficiently great to produce craters in the leaden blocks with rims raised above the level of their upper surfaces, leaving the surface around the crater normal. To determine the comparative power developed, the rim of the crater

was cut through down to the level of the upper surface of the block, and by filling the crater to that level with water from a glass tube graduated in cubic cm., the amount of lead displaced was determined. The greater the number of cubic cm. of lead displaced, the greater the development of strength by the gun-cotton. The leaden blocks used were of sufficient size—15 cm. cubes—to admit the use of a considerable weight of gun-cotton.

Gun-cotton cartridges 38 mm. diameter, 50 mm. high, and weighing 63 g.:

Experiment 7.—1 dry cartridge displaced 27 cbcm. lead.

Experiment 8.—1 wet cartridge detonated by dry one above it displaced 36 cbcm. lead.

Experiment 9.—8 dry cartridges, one above the other, displaced 33.5 cbcm. lead.

Gun-cotton cartridges 60 m. diameter, 50 mm. high, and of different weights:

Experiment 10.—1 dry cartridge, 1.1 sp. gr., weighing 153 g., displaced 60 cbcm. lead.

Experiment 11.—1 dry cartridge, 1.28 sp. gr., weighing 178 g., displaced 90 cbcm. lead.

Experiment 12.—1 dry cartridge, 1.28 sp. gr., weighing 175 g., displaced 90 cbcm. lead.

Experiment 13.—1 cartridge as in 11 and 12, but containing 18 per cent. moisture, and hollowed out to receive a dry priming charge of 32 g., 1.1 sp. gr. The weight (dry) of gun-cotton same as in 11 and 12, and the cubic space same as 10, 11 and 12. Amount of lead displaced 148 cbcm., thus displacing $2\frac{1}{2}$ times as much lead as in 10, and $1\frac{3}{4}$ times as much as in 11 and 12.

Experiment 14.—Same as in 13, only the priming charge was 12.5 g.(?); so the whole cartridge had 12.5 g.(?) less gun-cotton in it; but the poorer result was not owing to this difference. Amount lead displaced 110 cbcm.

Experiment 15.—Cartridge as in 13 and 14; for priming charge there were used 8 discs, each 38 mm. diameter, placed one above the other, the detonator placed in the upper disc. Weight of each disc in priming charge 63 g. Amount of lead displaced 143 cbcm.

If, then, as has often been shown, the action of the last cartridge in long charges is reduced, in this case the eighth, it still fully served its purpose in developing the full power of the wet gun-cotton which it detonated.

Experiment 16.—3 cartridges, placed as before, each 60 mm. diameter, 50 mm. high, and of 1.1 sp. gr., weighing together 410 g., all dry, displaced lead 120 cbcm.

Experiment 17.—3 similar cartridges, but of 1.3 sp. gr., and weighing 488 g., displaced lead 200 cbcm.

Deductions.—Gun-cotton of a decidedly higher sp. gr. than 1.1 develops a materially greater power, and this increase is greater in proportion than the increase in the absolute weight of gun-cotton employed.

It is therefore generally advantageous for the development of power to employ gun-cotton of as high sp. gr. as possible, more especially in case the space for the reception of the charge is limited. However, the following experiments made with gun-cotton-charged-shell, and with charges not in contact with the objects to be destroyed, show that under circumstances different from the preceding the advantage of gun-cotton of a higher sp. gr. does not manifest itself so directly.

Effect of Gun-Cotton upon Objects not in Contact with it, but Separated by an Air-Space.

In order to secure a starting-point for comparison in the following experiments, the preliminary experiment (1) was made:

(1). A disc of gun-cotton 60 mm. diameter, 1.2 sp. gr., and weighing 181 g., was placed upon a piece of wrought iron 30 mm. thick and detonated.

The effect was to make a bowl-shaped indentation in the iron of the diameter of the gun-cotton disc and of 8 mm. depth in the centre. In addition to this, the effect on the under side of the iron was considerable: it was nearly broken through.

(2). A disc of gun-cotton 60 mm. diameter, 1.3 sp. gr., and weighing 181 g., was placed 34 mm. above a similar piece of iron to that used in (1) and detonated. It made an impression 55 mm. diameter and of a depth from 3 to 4 mm.

(3). A disc of gun-cotton 60 mm. diameter, 1.1 sp. gr., weighing 156 g., was placed exactly as in (2) and detonated. It made an impression 55 mm. diameter and of a depth from 1½ to 2 mm. Moreover, in (2) and (3) the iron was separated lengthwise of the fibre, the crack running through to the under side.

The effect in general decreased, and in such way that the effect of (1) bore about the same relation to that of (2) which that of (2) bore to that of (3), and the differences of effect were considerable.

(4). A disc of gun-cotton, as in (2), of 1.3 sp. gr., was placed 100 mm. from the iron and detonated. Only traces of an impression were made.

(5). A disc of gun-cotton, as in (3), of 1.1 sp. gr., was placed 100 mm. from the iron and detonated. Traces of an impression were made, but fainter than in (4). The difference between effects in (4) and (5) was not very marked.

(6). Suspended in air 20 cm. from the trunk of a pine tree of 9 cm. diameter, and 35 cm. above the ground, was a charge of gun-cotton weighing 254 g. Upon the ground under the charge lay an oak plank 25 mm. thick. Upon detonation the bark was peeled off the pine tree, and a piece in the direction of its length was split from the plank.

(7). A charge of gun-cotton weighing 400 g. suspended in the same manner at 15 cm. from the trunk of the pine tree. Upon detonation the tree was cracked and another piece was split off the plank.

Deductions.—With an air-space between the gun-cotton and the object to be destroyed, the effect is very much reduced. With a greater air-space, the effect produced by gun-cotton of 1.1 sp. gr. does not differ materially from that produced when the sp. gr. is 1.3.

B.—*Explosive Experiments with Gun-Cotton Enclosed in Cast-Iron Shell.*

The gun-cotton was in the form of discs 139 mm. diameter and 50 mm. high, and of 1.1 sp. gr. The cavity in the shell was such as to receive these discs. The walls of the shell were 32 mm., the bottoms 60 mm., and the heads 120 mm. thick.

Two leaden blocks, 15 cbcm. in volume, resting upon a perforated iron plate, received the base of the shell. The upper block was always more or less destroyed. The effect could, however, be more accurately measured by the upsetting of the under block, and from the quantity of lead forced from its under side into the hole of the iron plate.

Experiment No. 1.—The shell was charged with 5200 g. dry gun-cotton, the detonator being placed at the greatest distance from the support—*i. e.*, in the uppermost disc.

Experiment No. 2.—The shell was charged with gun-cotton containing 20 per cent. of moisture; the same weight of dry gun-cotton, however, as in No. 1. The upper disc was dry, and served as a priming charge to detonate the wet ones.

Experiment No. 3.—The charge of the shell consisted of gun-cotton containing 20 per cent. of moisture; the discs were hollowed out in line with the axis of the shell to a diameter of 50 mm. In the head of the shell was a disc of dry gun-cotton as a priming charge to detonate the wet.

In analogy with the explosive effects of unconfined gun-cotton, it appeared evident that there would be a specially powerful effect produced down through open central channel upon the support.

Experiment No. 4.—The shell was charged with gun-cotton containing 20 per cent. of moisture, though the bottom disc, weighing 930 g., was dry, and in it was placed the detonator.

The effect in 3—hollow-charged—was least; then came 1, next 2, and in 4 the effect was greatest, the disc which was detonated by the detonator, and which then detonated the other discs, being almost in contact with the object to be acted upon.

In experimenting, it has manifested itself that gun-cotton detonated by a fulminate-of-mercury detonator acts more powerfully than when detonated by other gun-cotton. In this manifestation the immediate distance to which the detonation of the detonator acts plays a *rôle*. As soon as this distance is exceeded we conclude that the gun-cotton is no longer detonated by the detonator, but by other gun-cotton which it has detonated.

To investigate more closely the influence of the detonator upon the violence of the detonation, the following experiment was made:

Experiment No. 5.—Three 15 cbcm. leaden blocks were hollowed out in the middle to a diameter of 23 mm.; a fourth block of the same size was only half bored through. These four blocks were placed one on top of the other, the half-bored one on the bottom, and were secured in place with iron straps. The cavity down through the centre of the leaden blocks, being 52.5 cm. in length, was provided with a charge of gun-cotton 45 mm. long, made up of several discs 22.5 mm. in diameter, the lower disc resting on the bottom. The upper disc was bored out to receive the detonator, which last was connected to a string fuse which passed through a hole in a lead plug fitted into the cavity in the upper lead block.

After detonation it was found that the leaden blocks were each divided into four quite regular pieces; upon placing the pieces together again, it was seen that the detonation had increased the central hollow very materially—to 230 mm. diameter in the upper part, and to 130 mm. diameter in the lower part. The proportional spheres

would be about as 6 : 1, so that we must conclude that the part of the charge detonated by the detonator produced six times the effect which was produced by that part of the charge detonated by gun-cotton.

We infer from these experiments that it may be possible, by changing the physical characteristics of gun-cotton, or by a different manner of producing detonation of the same, to secure a considerably higher development of power.

The detonation of the detonator caused the gases from the detonated gun-cotton to be powerfully effective; but these powerful gases, acting upon the elastic gun-cotton, lose some of their force, and are not capable of developing gases of the same power from the remaining gun-cotton. So far, it has not been possible for us to continue the experiments within leaden blocks, so that we might have employed gun-cotton of 1.3 sp. gr., or perhaps nitroglycerine, which is not elastic; yet the experiments with unconfined charges afford ample ground for comparison.

Nor have we had the opportunity to try the effect of shell filled with gun-cotton of 1.3 sp. gr. upon objects of sufficient resistance to endure and show full amount of destructive work done, and upon objects generally.

The difference in effect between wet and dry gun-cotton manifested itself very slightly in the experiments made with shell, yet it is possible that this difference may exist to a considerable extent in confined charges, and that it may have only manifested itself upon the object confining it. The base of the shell was amply thick for the purpose. This relation could not be proven, as cast iron is a material which does not offer sufficient resistance to permit the different effects to be fully developed.

It is improbable that confinement, on all sides of equal strength, would exert any influence upon the development of power in compressed gun-cotton.

If a disc of compressed gun-cotton is detonated upon an armor-plate, or upon a sufficiently resisting piece of wrought iron, an exact impression of the face of the gun-cotton in contact will be left upon it, the dimensions of the impression being exactly those of the face of the gun-cotton in contact. The effect of the detonation only goes beyond this limit in that the immediately affected particles of the iron carry with them parts of those adjoining them. The gases generated by the detonation had, therefore, in the first instance, and as

long as they exerted their maximum force, the exact form and occupied the same space as was occupied by the gun-cotton before detonation. How suddenly the power is exerted is shown by the following experiment: If between a gun-cotton disc and the iron plate there be placed a coin, after detonation the raised figures and letters thereof will be left impressed in the iron. If, instead of a coin, a leaf is used, then after detonation the whole frame or skeleton of the leaf is left raised upon the iron. The larger as well as the smaller ribs of the leaf protected the underlying parts of the iron, while the thinner parts between could not yield such protection, and under them the impression is deeper.

C.—*Explosion of Shell upon Railway Rails.*

We exploded a number of shell upon such objects as in actual practice it would often be desired to destroy; and for charging them we employed granulated gun-cotton.

15 cm. cast-iron shell 2¼ calibres in length and of 2 litres charge capacity were filled with granulated gun-cotton. After charging, the shell were filled with melted paraffine, which will be more fully explained later. The dry as well as the wet grains of gun-cotton were coated by dipping in acetic ether. The explosive charges were:

Experiment No. 1.—Dry granulated gun-cotton 1200 g.

Experiment No. 2.—Gun-cotton with 25 per cent. moisture and 250 g. of dry.

Experiment No. 3.—Gun-cotton with 25 per cent. moisture and 150 g. of dry.

Experiment No. 4.—Gun-cotton with 25 per cent. moisture and 100 g. of dry.

Experiment No. 5.—Wholly paraffined gun-cotton and 300 g. dry, gelatinized.

Experiment No. 6.—Wholly paraffined gun-cotton and 200 g. dry, gelatinized.

Experiment No. 7.—Gun-cotton with 25 per cent. moisture and a priming charge 31 mm. diameter of 35 g.

Experiment No. 8.—Gun-cotton, dry, and a priming charge of 35 g.

Experiment No. 9.—Wholly paraffined gun-cotton, 150 g. dry gun-cotton, and a priming charge of 35 g.

Experiment No. 10.—Half a shell, divided lengthwise, filled with 1000 g. of gun-cotton in prisms (having a volume of 140 cbcm).

Experiment No. 11.—Two prisms as in 10, of 154 g. each, placed directly upon the base of a rail.

Experiment No. 12 —One such prism as in 11, laid upon a rail.

Each shell was provided with a priming charge 16 mm. diameter, weighing 9 g., for the reception of which a hole was left; in the priming charge was inserted the detonator of 1 g. fulminate of mercury.

The shell were placed upon a platform composed of three rails, bottom side up, the heads brought as close together as possible.

All the shell exploded perfectly. The effect was nearly the same in all. The rails were generally cut through, and where this did not happen an equal development of power was manifested in some other way.

No. 10 produced no greater effect than the others, which tends to show that granulated gun-cotton acts as powerfully as do compressed gun-cotton discs.

In 11 the rail was smoothly cut twice, in 12 once, the effect in comparison with the preceding being greater; which goes to show that confinement does not increase, but does perceptibly reduce, the effect upon the immediately underlying object; which is explained by the fact that the 20 mm. thick wall of the shell separated the gun-cotton from the rail. We note that we are speaking of the immediate and direct effect upon the underlying object. There is a general effect, which is exerted upon more distant objects, which must not be confounded with the former, and in which such short distances as 20 mm. need not be considered. This difference furnishes the reason why only relatively reliable results can be obtained in experiments where the effect can only be produced on one side and upon an object in immediate contact, and why our experiments, one time with the gun-cotton in immediate contact with the object, another time confined within an interposing object, did not furnish regular and well-defined results.

If, moreover, no more effect is produced upon the support by nine discs of gun-cotton than by one (see Experiment A, 5*a*, 5*b* and 6), it does not follow that in the former there is not more power developed proportionally to weight of gun-cotton. At all events, even with exclusive reference to effect, wet gun-cotton is preferable to dry, as where it is desired to destroy such objects as walls, arches, armor-plates, etc., with unconfined charges, care being taken to make contact surface between gun-cotton and object to be destroyed as great as possible.

Experiment No. 13.—A shell charged with granulated gun-cotton, wholly paraffined, provided with a priming charge 31 mm. diameter, weighing 65 g., placed in a cavity left therefor. Failed to detonate; portions of the charge burned.

Experiment No. 14.—A shell charged with granulated gun-cotton, wholly paraffined, provided with a priming charge 31 mm. diameter, weighing 100 g., was perfectly detonated.

In case a shell is charged with granulated gun-cotton and the charge is not cemented together, and to the shell, by means of melted paraffine, a much heavier and larger priming charge will be required to produce detonation.

Experiment No. 15.—A 21 cm. cast-iron shell charged with 4200 g. of dry granulated gun-cotton was placed upon a platform composed of a double layer of rails—five rails resting on their bottoms upon two wooden sills. On top of these were four rails, bottom up, in the interstices between the heads of the five bottom ones. The wooden sills were 1 m. apart.

The shell was covered to a depth of ½ m. with earth. The effect of the explosion was very marked. All the rails were cut through, most of them several times. In addition there was a hole made in the ground ½ m. deep. A bomb-proof cover would, in the light of this, be difficult of attainment.

D.—*Effect of Gun-Cotton and Gun-Cotton-Charged Shell in the Ground.*

Experiment No. 16.—A 15 cm. shell filled as before with granulated gun-cotton and buried 1 m. under ground produced in light earth, also in somewhat heavier earth, as loam and sand, a crater 60 cm. deep and 2 m. diameter.

Experiment No. 17.—A 15 cm. shell filled with 2100 g. ordinary cannon powder produced a crater 50 cm. deep, 2 m. long and 1½ m. wide.

Experiment No. 18.—A 15 cm. steel shell 6 calibres long, charged with 8.9 kg. granulated gun-cotton containing 25 per cent. of moisture, 1 kg. of dry grains, and a 35 g. priming charge, was so buried that its apex was 1 m. under ground, while its base was ½ m. under. The crater produced was 1.3 m. deep and 4 m. diameter.

E.—*Experiments Comparing Effect Produced by Compressed Gun-Cotton Discs and Granulated Gun-Cotton.*

The ground in which the experiments were conducted is a light sandy loam.

Experiment No. 19.—A tin case 3 calibres long, of 7½ l. capacity, filled with

6300 g. wet granulated gun-cotton } 8 mm. cubes,
300 g. dry " " }
50 g. priming charge,

5620 g. total weight of gun-cotton when dry,

was buried so that one end was 1.2 m. under ground, the other only .9 m. The crater produced was 1.1 m. deep and 3.3 m. diameter.

Experiment No. 20.—A charge of the same form as in 19, but consisting of wet gun-cotton discs of 8.3 kg. dry weight, and provided with a 50 g. priming charge, was buried as in 19. The crater produced was 1.3 m. deep and 4.1 m. diameter.

Experiment No. 21.—A tin case 6 calibres in length and of 15 l. capacity was filled with 11,150 g. of dry granulated gun-cotton (8 mm. cubes, gravimetric density .75) and provided with a priming charge of 50 g., then buried so that one end was 1.2 m. and the other was .6 m. under ground. The crater produced was 1.58 m. deep and 4.45 m. diameter.

Experiment No. 22.—A charge composed of wet gun-cotton discs of 16.6 kg. dry weight, and provided with a priming charge of 50 g., was buried as in 21. The crater produced was 1.56 m. deep and 5.1 m. diameter.

A piece of wrought iron 3 cm. thick and 10 cm. square was in the first two experiments placed directly in contact with and under one corner of the tin cases, and in the second two it was placed parallel to the sides of the cases and 15 cm. below, and the interval filled in with earth. In 19, 21 and 22 the piece of wrought iron was compressed to about the same degree, but in 20 the compression was perceptibly greater. In 19 and 20, the iron being in immediate contact with the cases containing the explosive, the discs of compressed gun-cotton proved more powerful in their action than the granulated gun-cotton.

Experiment No. 23.—A piece of railway rail .5 m. long, 12 cm. high, with 10 cm. base, was put upon two pieces of pine each 10 cm. square, placed 25 cm. apart, the whole set 1.25 m. below the surface. Earth was filled in 25 cm. above the top of the rail. A tin case, as in 19, filled with 5620 g. dry granulated gun-cotton and provided with a 10 g. priming charge, was laid over the middle of the rail and at right angles to it; then the hole was filled in to the original level. After explosion the rail was cut in three parts across its entire profile;

its base was pressed into the wood to a depth of 1 cm. The pieces of pine were not otherwise injured. The crater produced was 1.1 m. deep and 3.1 m. diameter. The pine pieces and fragments of rail were found 1.5 m. in the ground.

Experiment No. 24.—A charge of the same size as the tin case just used, composed of compressed gun-cotton discs of 8.3 kg. dry weight, and provided with a 50 g. priming charge, was located exactly as in 23.

The rail was cut to pieces almost in the same manner as before. There were only two pieces, however, out of which, towards the middle, a piece was broken from the upper surface in each. The base of the rail was not pressed into the pine supports, but they were cut in two straight across the middle. They evidently did not offer as much resistance as those used in 23. Beyond being cut in two they suffered no damage. The crater produced was 1.5 m. deep and 3.5 m. diameter, somewhat larger than in 23. The pieces of rail and wood were found 1.65 m. below the surface.

In both 23 and 24 the rail was cut, though placed 45 cm. below the charge. The bottoms of the craters produced were respectively 40 cm. and 80 cm. below the location of the charge. The pieces of rail and wood were forced into the ground to a depth of 90 cm., and at that depth the sandy earth was pulverized.

These experiments demonstrate that gun-cotton in either form produces powerful effects, not only in its immediate vicinity, but at appreciable distances.

It appears from these comparative experiments that, on the whole, the effect of equal volumes of granulated gun-cotton and compressed gun-cotton discs is about the same. The more than a third greater weight of gun-cotton in the compressed discs is scarcely realized in the general effect where a very considerable weight is employed and the object to be acted upon is not in immediate contact with the charge.

Whether, with regard to other objects, and under other circumstances, the advantage of greater weight of gun-cotton in the use of the compressed discs, instead of granulated gun-cotton, will make itself felt, remains unsettled; but from the preceding experiments we are constrained to think it will do so in a very slight degree.

We are further of the opinion that it is very doubtful whether by the employment of specifically heavier or higher explosives than compressed gun-cotton, as explosive gelatine, a mixture of nitrate of benzol and aniline with nitric acid, or lower oxides of nitrogen, etc., in shell, a greater effect would be produced.

In actual practice the shell will seldom be in contact with the object to be destroyed by their explosive action; they will generally be somewhat removed, as, in firing against masonry or armor, they will not be in contact therewith their whole length—only slightly or not at all; and it is just at short distances from the object that the difference between a high and a lower explosive is realized.

In cast-iron shell with thick walls, the effect of the higher explosive would, perhaps, not be otherwise realized than in the pulverization of these walls, a result not generally desired.

In order to obtain a satisfactory basis of comparison of the development of power, and its effect upon objects from the different explosives, they should be experimented with under conditions of their probable use in actual practice.

We copy a few paragraphs from the work of Lieutenant-General Brialmont, already referred to:

"Ordinary 21 cm. steel shells charged with 14½ kg. of powder, fired from the Krupp rifled 21 cm. mortar at 45° elevation, forced themselves from 2 m. to 2.6 m. into the sandy earth of the firing ground at Meppen and produced elliptic craters 1.2 m. to 1.4 m. deep, 3.2 m. to 4.8 m. long, 3.2 m. to 4.0 m. wide. Fired at 28° and 60° elevation, less effect is produced.

"A steel torpedo shell 6 calibres in length, charged with 36 kg. of powder and fired at 35° elevation, produced a crater 1.0 m. to 2.2 m. deep, 3.2 m. to 5.0 m. long, 2.6 m. to 5.0 m. wide, which corresponds to a mean displacement of 7 cbm. of earth.

"In comparison with the foregoing, it appears that 21 cm. steel shell charged with gun-cotton force themselves 4 m. into the ground, there, lying nearly horizontally, produce craters 2.4 m. deep and 4.8 m. diameter, which corresponds to a mean displacement of 15 cbm. of earth.

"Arches made of the best concrete and 1.45 m. thick will be protected against the ordinary shell thrown from the 21 cm. rifled mortar by a covering of sandy earth 2.5 m. thick; against steel shell charged with 14½ kg. of powder by a similar covering 3 m. to 3.5 m. thick; and against torpedo shell charged with gun-cotton by a similar covering 5 m. thick.

"An earth-covering 5 m. thick will not be practicable, as fortifications would thus become too high, and the expense would be enormous. It is therefore suggested to leave off the earth-covering entirely and substitute a layer of granite or porphyry .8 m. thick, or a layer of Portland cement 1 m. to 1.2 m. thick.

"The experiments carried on in Silberberg in 1869 appear, however, to have demonstrated that perhaps this would not be sufficient protection even against the shell from the rifled mortar, when charged with powder only, as, since they made indentations ½ m. to ⅔ m. in depth, a second shell striking in the same spot would break through the arch."

Lieutenant-General Brialmont therefore believes that he cannot yet make a definite proposition; he suggests, however, that arches be made of the best concrete, 1 m. to 1.5 m. thick, and that they be covered with at least 3 m. of sandy earth. If this be not sufficient, then concrete must be substituted for part of the earth, or the depth of earth must be increased; or there must be added plate iron on the under side, which would appear to be the simplest and cheapest method.

The tendency appears to be toward the armored turret. We believe, however, that with large charges of gun-cotton even turrets can be effectively attacked.

Altogether, it appears that Lieutenant-General Brialmont regards the effect of gun-cotton shell, and their influence upon the future construction of fortifications, as of great importance.

Submarine Blasting with Compressed Gun-Cotton.

Blowing up the Tugboat Mathias Stinnes I, Sunk in the Rhine near the Railway Bridge of Rheinhausen, below Duisberg, by the Author and the Engineer Math. Rossenbeck.

The tug was a strong iron vessel built in the early days of such constructions, and was very solid in all its parts. Its stern was 200 m. from the railway bridge, which rests upon massive piers, and 100 m. from the right bank of the river, the hull pointing down stream and lying about parallel with the current. At average high water there were 2 m. depth above the deck aft, and 6 m. forward. The wreck was to be removed, so as to obtain a certain depth of water over it, to realize which it was necessary to entirely remove the after and midship portions. The current is so strong that it is impossible for a diver to descend without support against it.

A wooden barge was fitted with an iron shaft across its deck, on which, beyond the barge's side, an iron ladder was fitted to move freely in guides. When the ladder hung at the proper angle, it was held in place by a pulley, the lower part resting upon the wreck or some detached part of it, or upon the bottom, while the upper

part projected at least 2 m. above the shaft. To the ladder was attached an iron shield ¾ m. broad, which deflected the current. The ladder and its shield were raised and lowered by a pulley. The diver could reach the wreck by means of the ladder, and protected by the shield he could work, mostly with his left hand.

A second barge, of the largest kind, was decked over solidly and provided with a crane, by means of which and a chain the portions blown off were hoisted up.

Owing to the proximity of the railway bridge, and to avoid injuring it, great explosive charges could not be employed; nor would they have facilitated the work, but would have retarded it. No large charge, even one of 1000 kg. of the most powerful explosive, would have broken up the wreck in such a way as to make it possible to hoist up and get rid of the separate pieces. The explosion of such a charge would have produced a conglomeration of pieces of the wreck which, holding tenaciously together, could not have been hoisted up; nor would it have been possible then to finish the work with divers.

It became necessary, then, to blow off single parts by means of moderate charges, and hoist these up by means of barge and crane; so there were provided wooden boxes filled with 10 kg. of compressed gun-cotton, which were placed and exploded singly or in pairs.

The diver would descend by the ladder, place the charge advantageously, which, on account of the strong current, sometimes required hours to accomplish. He would come up, the ladder would be raised, the barge hauled out into the stream, and the charge exploded by electricity. The barge would be hauled back, the diver would descend and sling detached parts with the chain, an operation often consuming hours; then it would be attempted to raise them. Sometimes the attempt would be vain, as the apparently detached part was still connected with the wreck.

The plates were first raised, then the frames, the rudder, later the boilers, parts of the paddle-wheels, of the shaft, and of the engine. The shaft was of steel, 15 cm. diameter, and it was smoothly cut through several times with double charges of 20 kg. gun-cotton.

Powerful as is the effect of gun-cotton, yet there were over 100 explosions, consuming 1200 kg., necessary to remove the wreck to the desired depth. The after half was mostly raised; the other half was buried in the sand through violence of the explosions. The forward part, beyond the shaft, was very slightly worked upon, as it already lay under the desired depth of water.

It was again shown in this case that it is not possible to annihilate a vessel by explosion. Iron constructions cannot be made to disappear by explosion, unless they are raised and carried away afterward, or are forced under the bed of the stream thereby.

It is a different thing to sink a floating vessel. Explosive charges of 20 kg. gun-cotton, acting upon a suitable place on the outside of a ship and in immediate contact with it, will make a hole, but whether the damage will be great enough to sink her is doubtful. As to the effect when not in contact, we have observed that the explosion of 100 kg. of gun-cotton in deep water produces but a very slight effect on a floating object 100 m. distant; while the effect against rigid objects, as buildings, etc., of 100 kg. of gun-cotton exploded upon the ground will be felt at 500 to 800 m. distance.

Wrecks of wooden vessels are readily shattered to such an extent by explosion that the tide in ebbing and flooding, or other current, will carry away the pieces; and we have destroyed a number of such wrecks on the coast of the North Sea and in the mouths of the Jade and Weser. The charges were placed by divers against the sides of the vessel, where it was possible; otherwise they were lowered down upon it. They consisted of 100 kg. gun-cotton placed in rather long boxes. With small vessels two to three such charges well placed are sufficient, while with larger vessels a considerably greater number would be necessary.

Blasting in the Adlergrund.

In the Baltic, between Bornholm and Rügen, lies the Adlergrund, a shoal formed by bowlders resting on the bottom. The Royal Government had been deepening the shallowest places by hoisting up the bowlders by means of vessels provided with the necessary appliances. Divers descended and attached the chains or claws to the stones for raising them. In order to loosen the bowlders in their beds, and so facilitate the work, there were exploded numerous charges of 10 kg. gun-cotton in water from 4 to 6 m. deep. These explosions loosened each from two to four bowlders of about 2 cbm., forcing them well out of their beds.

Rock-Blasting in the Rhine to Deepen the Channel between Bingen and Coblenz.

In many places dangerous shoals exist in the Rhine, formed by rocks on the bottom; of these the Bingerloch is the most dangerous

and best known. To remove these shoals the rocks are drilled from floats and other vessels to a depth proportional to the height of stone to be removed; the holes are filled with powder and tamped with sand, and the charges are exploded. After 10 to 20 explosions, vessels provided with diving apparatus are hauled over the exploded ground, and the *débris* is hoisted up and disposed of.

It is our opinion that if high explosives were employed in this work instead of powder, the operations of removing the *débris*, which now are the most expensive part of the work, would be simplified and cheapened. It would not be necessary to drill the blast-holes so deep, as the detonation of a high explosive in them would shatter the rock from the beginning to the end of the hole; while, using powder, the lower third of the hole and surrounding rock remains, as a rule, intact. High explosives are not employed, because, in case of failure to explode, which will happen now and again, the explosive would remain in the rock, and might be accidentally exploded by the workmen while at work clearing away the *débris*, resulting in loss of life and property.

Using nitroglycerine preparations, this might readily occur, as these explosives are not made insensitive to detonation by concussion, no matter how long left in water. Using gun-cotton, however, as has been described by the author in a previous publication, the charges can be arranged in cartridges so that after a certain time, say 24 hours, the charge will certainly be saturated, and so become insensitive to explosion by concussion or by the detonation of the detonator.

Though advantages will be realized by the use of gun-cotton in this sort of work, yet it is our opinion that with its use, or that of any other high explosive, drilling will still have to be resorted to. In deep water, which may be regarded as tamping, high explosives simply placed upon the bottom and detonated do not accomplish enough work in the way of breaking up the surrounding rock, hence the cost of explosive necessary to accomplish the desired work would be too great. The only case we think of where it would be advantageous to blast without drilling is where a large surface of rock is to be removed to a very slight depth, 10 to 15 cm. Here the increased expense for explosive material would be provided for in the saving by not drilling or removing the *débris*, and the saving of time.

Paraffining Gun-Cotton.

(1). *Paraffining dry gun-cotton so that the paraffine permeates it entirely and occupies the place of water in wet gun-cotton.* Wet gun-cotton in store loses its moisture in time, unless it is hermetically sealed, and has to be dampened again. To save this labor, it has often been suggested to substitute paraffined for wet gun-cotton, because paraffine does not evaporate.

This suggestion would be very useful if paraffine were calculated to take the place of water in the premises. This is in nowise the case. Paraffined gun-cotton is a substance which lies between the wet and the dry, and has lost the best characteristics of both.

The chief advantage of gun-cotton containing 25 per cent. of moisture is its incombustibility. This peculiarity takes from it, for purposes of handling, storing and transportation, the character of an explosive, and it is a great advantage to be able to store it in this condition, where very large quantities are concerned. This is peculiarly realized in case of fire in the magazine or its vicinity; if the fire should burn a considerable time, owing to the presence of other combustible materials, the gun-cotton in store might be spoiled: danger can never arise.

So long as spontaneous decomposition cannot be considered absolutely impossible, will wet gun-cotton be preferable to all other explosives derived from nitrating organic substances, which are all inflammable, as with it there cannot occur spontaneous combustion. The characteristic of non-combustibility is what particularly recommends wet gun-cotton for military use, and makes it especially suitable for use in sea mines, as in this use circumstances combine to make it necessary to accumulate large quantities of explosive in one place. Such accumulation, in case of fire, is a great danger, as heat enough may be developed to produce an explosion.

Paraffined gun-cotton does not, however, possess the characteristic of non-combustibility, but is ignited by any and every little flame which may reach it, and, once ignited, it burns with the rapidity of dry gun-cotton. The rapidity with which fire spreads and develops in the explosive is the real measure of the danger which exists in a magazine filled with it.

For the further judgment of paraffined gun-cotton the following incident occurring at the factory in Walsrode may be cited: Pieces of gun-cotton only partially freed from acid were paraffined. After

two years it was found to be decomposing; green spots and cheesy places made their appearance; the whole mass became soft and fluid. In other words, the same phenomena were observed as in the decomposition of dry gun-cotton of poor quality. In a similar grade of wet gun-cotton this decomposition has not been observed.

Not only does paraffining not prevent decomposition, but it really encourages it, everything considered. Paraffined gun-cotton is produced from the wet by drying it and then dipping in a paraffine bath of 65° C. and leaving it therein until the paraffine has permeated all parts. It takes from ½ to 1 hour, according to the size of the piece. If the bath is cooler, then a longer time is required.

This process is always injurious to the gun-cotton, for it is certain that at the temperature of 65° C. nitrous acid is evolved, as may be shown by the iodide-starch-paper test. The acid so evolved is shut in by the paraffine, and cannot evaporate, as can the acid which time develops in wet and dry gun-cotton not hermetically sealed.

Experience in the factory at Walsrode has amply demonstrated, verified by the iodide-starch-paper test, that a not very stable article of gun-cotton which has opportunity to evaporate becomes more stable after a lapse of years. To be sure, the evolved acid will in part have been taken up by the chalk; the remainder will have disappeared, leaving the gun-cotton in a stabler condition. Slight traces of nitrous acid are developed in all gun-cotton, even at low temperatures. Digesting gun-cotton in warm, or sufficiently long in cold water, traces of nitrous acid will be noted in the water by the addition of sulphuric acid and iodide-zinc-starch solution. In this direction we made the following experiment: A sample of gun-cotton was washed until no trace of nitrous acid could be discovered in the wash-water. The sample was then placed in the drying cupboard for eight days and kept at the temperature of 30° C., again examined and traces of nitrous acid discovered. The same experiment repeated several times with the same sample invariably resulted in the same way. Wherefore we are constrained to believe that all gun-cotton contains nitrous acid.

But all potassium nitrate, as obtained in commerce and used for the manufacture of powder, contains nitrous acid. We applied to one of the most celebrated firms of chemical manufacturers for melted potassium nitrate free from it, and received as reply that they had not succeeded in producing such. Thereupon we attempted to produce it in our own laboratory by purifying with great care some that we

had on hand. After purification it was placed in a tightly closing gas flask. Upon examination after several months had passed, the saltpetre was found to again contain nitrous acid.

Professor Himly, of Kiel, expressed himself several times to the author to the effect that "all nitro-compounds are not stable, all organic substances decompose; for explosives only inorganic substances should be employed." True as this is in theory, practice does not warrant strict acceptance of the conclusion.

It will, however, even in the case of gun-cotton, be well to take every precaution in its manufacture; and later, in preparing it for explosive charges, too great reliance must not be placed in its safety, as is often done to the neglect of proper care.

We note, further, that when nitrous acid is evolved and combines with the chalk, forming calcium nitrate, it will not be injurious to the gun-cotton so long as not more acid is evolved than the chalk can absorb. In spite of this, however, acid reaction is obtained with the liquid iodide-starch or iodide-zinc-starch test, for the calcium nitrate is dissolved by the water used in digesting the gun-cotton; if sulphuric acid is added, free nitrous acid is liberated, and indicated by the reaction. Gun-cotton may in fact be acid-free, and yet upon investigation give nitrous-acid reaction. From all of which we infer that it is a vain effort to attempt to produce gun-cotton free from nitrous acid. The gun-cotton just discussed is, however, to be distinguished from such as still contains perceptible quantities of free acid, even nitric acid. In the case of the latter, it is our opinion that instead of improving with time, it will deteriorate and decompose. We have not discovered evidence that pulped and moderately acid-free gun-cotton will decompose by heat.

Returning to paraffined gun-cotton, we do not wish to be understood as having said that good gun-cotton would be decomposed to a dangerous degree by paraffining, but only that the process should be avoided when possible. Nor do we in general maintain that it is injurious to store good gun-cotton in hermetically sealed receptacles. We have, moreover, demonstrated that good gun-cotton so stored for years did not deteriorate, as proven by the iodide-starch test. We believe, however, that it will be better for all gun-cotton not to store it in hermetically sealed cases.

Turning to the physical characteristics of the paraffined gun-cotton, we find that its only similarity to the wet consists in being less sensitive to concussion than the dry, on account of which peculiarity

paraffining has been mainly recommended; it is, however, more sensitive to concussion, and to being ignited thereby, than gun-cotton containing 15 per cent. of moisture. To demonstrate this we made the following experiment:

Firing with the Mauser infantry rifle at short range at gun-cotton discs 15 cm. diameter and 5 cm. thick, those containing 15 per cent. of water withstood three hits, while the paraffined ones were ignited at the third hit.

The shocks which gun-cotton will have to withstand in its use in sea mines are readily withstood by it in the dry state; therefore it is not necessary to resort to paraffining on that account. The charges for fish torpedoes form an exception, in that they are frequently exposed to the enemy's fire, and for this very reason the use of paraffined gun-cotton would be unadvisable.

Now that it is demonstrated that paraffined gun-cotton is not sufficiently non-susceptible to concussion, it must also be acknowledged that it has lost its capacity for being detonated by 1 g. of fulminate of mercury, and that it can only be detonated by means of a priming charge of dry gun-cotton. Again, as paraffine does not evaporate, any gun-cotton which has been permeated with it cannot afterwards be utilized for priming charges; while, to use wet gun-cotton as such, it is only necessary to dry it.

We therefore reiterate our opinion that paraffined gun-cotton is not a good form of that explosive.

In the work of Manuel Eissler, Mining Engineer, New York, 1885, "The Modern High Explosives," great injustice is done to gun-cotton. He states that experiments in England have demonstrated that it is so sensitive to concussion that in a harbor defense of sea mines the whole defense could be neutralized by one countermine, which would, upon explosion, explode in succession all the mines of the system. As a matter of fact, there is no navy in Europe which does not almost exclusively employ this explosive for charging its sea mines, except where the old powder mines are still used, and principally because of its non-sensitiveness to concussion, as well as on account of its other favorable characteristics. And, also, in his descriptions of the chemical analyses and characteristics of gun-cotton, Mr. Eissler shows that he does not appreciate the nature and character of the explosive.

(2). *Paraffining dry gun-cotton so that the paraffine penetrates a few millimetres, and forms with the cotton penetrated an air and*

water-tight layer to protect the interior against moisture.—This practice suggests itself for the preparation of priming charges. The cavity for the detonator is closed by means of a piece of paper before dipping into the paraffine; after being thus treated these charges are protected against moisture for years. It is an improvement to coat the surface of the detonator cavity by applying acetic ether. Thus the priming charge is provided with a coating which will keep out moisture for a reasonable time after the paper cover has been broken through and the detonator inserted, even if placed in water. Sensitiveness to detonation is not decreased by this coat of dissolved gun-cotton, as it will detonate under water, and with water between the detonator and the surface of the cavity therefor.

For the priming charges of sea mines paraffining does not in any way recommend itself. However carefully it may be carried on, it is impossible to know whether the paraffine has penetrated just far enough or too far. There is always the possibility that the primer has been made unsusceptible to detonation by the detonator. Moreover, our observation goes to show that primers so prepared become cracked on the surface in time, thus opening themselves to the reception of moisture. A piece of gun-cotton is not a rigid object: it changes its form with change of temperature, and with change of moisture in the atmosphere.

These possibilities afford sufficient reason for the non-employment of paraffine in preparing primers for sea mines. It is better to protect them in store and in use by careful packing.

It should be further noted that air-dry primers will be detonated under all circumstances of season or weather by detonators containing 1 g. fulminate of mercury; so, if they be stored in dry and airy magazines, no fear need be entertained of failure to explode when good 1 g. detonators are used.

(3). *Paraffining Wet Gun-Cotton.*—Gun-cotton containing 25 per cent. of moisture may be penetrated several millimetres by paraffine, which, however, can go no farther, owing to the water within. The layer of paraffine remains perfect at medium temperatures, and affords a degree of protection against the evaporation of the moisture and against flaking. With considerable changes of temperature, as in freezing, numerous cracks form and the gun-cotton crumbles, thus neutralizing the two mentioned advantages. In the course of experiments made at the factory in Walsrode, it appeared that pieces of wet gun-cotton carefully paraffined might keep through one winter,

but not through two, without cracking. So many cracks formed that there was no more obstacle to the evaporation of the water nor to crumbling than in the case of similar wet, unparaffined cotton. Not unimportant is the fact that the paraffine layer enlarges the pieces, so that in a given space less gun-cotton can be placed. In pieces of 140 cbcm. the enlargement amounts to 12 per cent. Thus there is added to the gun-cotton an appreciable weight of a very combustible substance, which, with the wood of the packing cases, increases the danger in case of fire. Small pieces are not at all suitable for paraffining. If the paraffine layer is thinner than about 2 mm., then it does not serve its purpose for even a short time. Again, it is to be noted that it is uncommonly difficult and expensive to paraffine a large quantity of wet gun-cotton so that all the pieces shall be well covered, and, finally, that the sensitiveness to detonation is reduced.

It was experimentally shown that pieces of wet, paraffined gun-cotton could not be detonated by a 150 g. primer when they were not in immediate contact, though only 10 mm. apart. In unconfined charges, therefore, partial explosions and total failures might readily be realized.

The result is, that in view of the increased expense and other disadvantages, we cannot recommend the use of wet paraffined gun-cotton.

Coating Gun-Cotton by Immersing it in a Solvent Solution, as Acetic Ether.

This treatment has given very satisfactory results during the three years it has been exhaustively experimented with. The coating maintains itself well; cracking and flaking occur in a very slight degree. A lot of wet, coated gun-cotton was packed in a tightly closing box and stored, and another lot in an open box, and placed under water. Though cracks were developed here and there on a few of the pieces, yet the form and solidity given by the press were maintained. The time during which wet gun-cotton will retain its moisture depends materially upon the manner of packing. The coating is not impenetrable, but it does protect, to a considerable extent, against the reception of moisture in dry, and against its loss in wet, gun-cotton. The principal advantage of coating is its characteristic of making the pieces nearly as firm and tough as wood. This advantage will be appreciated by all who have noticed the condition of well-compressed

and packed gun-cotton after a long transportation. The coating is a protection against the formation of mould. If, however, the formation of mould is encouraged by the manner of packing and storing, and proceeds independently, as when it begins on the sides of the packing cases and gradually spreads over them and everything within, the pieces of gun-cotton will also be attacked, whether coated or not. If coated, however, the spores will not penetrate the coat, but remain on the exterior, and the mould may be washed or brushed off, and the structure and stability of the pieces will not be injured. It may be further noted that if wet gun-cotton upon which mould or other fungus is growing be placed in an airy place where it can dry, the growth of the fungus will be checked. It is also useful, when the cotton is in danger of injury from mould, caused by the climate or faulty packing and storage, to wet it with carbolic-acid solution.

Coating will recommend itself especially for gun-cotton to be used in fish torpedoes and sea mines, as it will have to withstand much transportation and handling and long storage. It will also be very useful in the case of cotton carried and used by troops in the field, and is absolutely necessary in the case of granulated gun-cotton for charging shells. In a shell so charged, upon being fired the charge will receive a violent shock, and be pulverized by the friction on the sides and base of the shell, and the powder may be ignited and so cause premature explosion. To avoid this, after charging the shell we pour in melted paraffine, which fills up the interstices, and upon cooling cements the grains to each other and the whole charge to the walls of the shell, making it a practically incompressible body, and prevents the upsetting of the charge or movement of any of its component parts. The coating on the individual grains prevents penetration of the melted paraffine, which is of great importance, as, if it penetrated, the sensitiveness to detonation would be so much reduced that priming charges would have to be increased to an extent that it would be difficult or impossible to insert them. All granulated gun-cotton is very much exposed to friction, and consequently to dusting, in handling, and only by coating does it become fit for transportation and war purposes. The sensitiveness to detonation is not at all reduced in coated gun-cotton, the dry remaining sensitive to the detonating action of the detonator, and the wet to the action of the dry. There is no reason why it should not be so, as in the process of coating there is no foreign matter added to the cotton. The acetic ether dissolves the cotton on the surface to the depth of the thickness

of a sheet of paper, and this dissolved cotton upon the evaporation of the ether remains as a thin, closely fitting skin. This skin is composed of dry gun-cotton, and it has, therefore, been truly said that coating by dipping in acetic ether makes wet gun-cotton combustible.

In the meantime, the word *ether* may encourage the idea that after the formation of the coating there may remain in it inflammable vapors of ether. This is, however, in nowise the case; the ether of the solution evaporates rapidly, leaving behind the hard, dry skin alluded to.

The quantity of dry gun-cotton thus produced is very small indeed, amounting in a prism of 230 cbcm. to 1 g., and to less in one of 140 cbcm.—less than ½ per cent. A case containing 50 kg. wet, coated gun-cotton would also contain about ¼ kg. of dry, a quantity in itself no source of danger, and which, in comparison with the quantity of combustible material existing about all stores of wet gun-cotton, need not be taken into consideration. Gun-cotton is generally packed in wooden boxes pitched inside. The weight of wood for a 50 kg. box is 15 kg., the pitch ¼ kg. Ample combustible material is therefore on hand to produce sufficient heat in a magazine, in case of a serious fire, to evaporate all the water of the gun-cotton in it. The ½ per cent. of dry gun-cotton produced by coating would not change the relations, as it is not flying about in the form of dust to be ignited by any chance cause. As we have already intimated, we are of the opinion that keeping the gun-cotton wet precludes all danger in case of fire in a magazine, as it prevents a quick and violent development of it. We believe, however, that in all methods of packing so far practised, a fire in the magazine would result in great injury to the gun-cotton, or, if the fire-extinguishing apparatus were not very perfect and sufficient, in its total destruction. But in these premises coating would not influence the result. Coated gun-cotton retains the odor of the acetic ether for a long time. It disappears after a time, which indicates that all the ether has evaporated. A change in the gun-cotton or in the coating is not perceptible. We have also demonstrated that neither in the coating nor immediately under the same is there any acetic acid formed. If, however, in packing freshly coated gun-cotton there should be manifested traces of acetic acid, which might have been formed by the acetic-ether vapors mixing with atmospheric air, no harm would be done, as it can in nowise be injurious.

The practice of coating gun-cotton by dipping in acetic ether has been called "gelatinizing."

GUN-COTTON SHELL.

It is admitted that the explosive effect of powder-charged shell against stone and iron arches, armored walls and turrets, is comparatively slight, and therefore great effort has been made to introduce shell charged with some high explosive. The most suitable explosive for the purpose appears to be compressed gun-cotton, for, while it is classed with the highest explosives, it is in a firm condition, easily handled, safe in transportation and storage, very slightly sensitive to concussion—not at all so in the wet state—chemically stable during long periods of storage, and it has been known and used with good results by military men for the last twenty years.

Starting from this point, it has been our object to make compressed gun-cotton the means of giving to shell a more powerful explosive effect. We have succeeded in finding a form of charge for shell, after extensive firing and exploding experiments, which appears to satisfy all demands, in that it not only admits of the firing of the shell from ordinary rifled ordnance, cannons or mortars without bore or premature explosions, but insures their explosion at the object. This charge, gun-cotton as well as fuse, will withstand the blow of the propelling powder gases, and there is no danger that either part of it will explode prematurely on account of such blow. We have demonstrated this by the following experiments:

(1). By firing a large number (over 200) of shell fully charged with gun-cotton from an 8.8 cm. cannon with 450 m. initial velocity. By firing from the 15 cm. rifled mortar with 200 m. initial velocity. By firing from a 15 cm. rifled cannon with 400 m. initial velocity. From the two last-mentioned pieces steel shells 6 calibres in length were also fired.

(2). By firing shell, out of which certain parts of the charge were left, against different targets, so that each part of the charge might be separately tested.

Besides the realized practical result that we fired these shells without any of them exploding in the bore, these experiments were made on the supposition that the shock of impact, at great final velocity, against a rigid object would be very much greater than that to be withstood in the bore by the action of the propelling powder gases against the shell. If the shell (from which the igniter has been removed, whose mission is to ignite the fuse on impact) withstands the former shock without exploding or even deforming any part of the explosive charge or fuse, it may with perfect safety be concluded that

it will under all circumstances withstand the latter shock; and, also, that when the igniter is added, premature explosions are not to be anticipated, as it is the same which has been used in the fuses heretofore employed and found safe. In addition to the igniter there is a detonator in connection with the fuse, which is necessary to detonate the gun-cotton. This detonator, which plays the most important part in experiments with gun-cotton shells, was differently constructed from the usual sort, and located in the charge with regard to the greatest safety, and was thoroughly tested, as the experiments show. In addition to the detonator described in our patent, we made use of another which satisfied all demands. After a combination of wet and dry gun-cotton is accepted as suitable for shell charges, the remainder of the problem is one of fuses, difficult, to be sure, but which we believe we have entirely solved.

The following are the experiments which are to demonstrate the power of resistance against shocks of our gun-cotton charges for shell:

(*a*). We fired loaded shell against rigid targets at short range, the igniters, which we regarded as out of the sphere of the experiments, were left out; otherwise the shell were completely charged and fused. The igniters were omitted because percussion fuses were used, which, in connection with them, would have been ignited upon impact and so have detonated the detonator. The shell struck with great final velocity, about 420 m.

The targets were earth-banks, hard-wood structures, and wooden structures covered with wrought-iron plates. We found that the shell withstood the shock of impact well, not detonating when the igniter was removed. We increased the strength of the wrought-iron plates on the target as far as the tenacity of the shell permitted, and found that so long as the empty shells fired against it did not break up, the loaded shells would also remain intact. When the shell breaks upon impact, the parts of the charge in their forward movement come into direct contact with the iron, and the friction sets fire to the gun-cotton and detonates the fuse. There were numerous cases in which the shell broke, lodging fragments in the earth-bank behind the target 1 m. deep, without there occurring burning or detonation of any part of the charge.

(*b*). We fired against the same targets shell charged only with gun-cotton, or only with the fuse and detonator—the igniter left out.

The former we afterwards opened by placing a gun-cotton car-

tridge upon them and detonating it, and if the charge of the shell was not detonated thereby or burned, it was shown that the individual grains were not bruised, and that the charge, as a whole, had not been set forward or backward by the shock of discharge or impact. The latter we filled with peas and a wet priming charge, and after firing they were opened by boring out the bottom, when it was shown that the detonator had not been detonated.

From the 8.8 cm. gun we fired shell of the ordinary form, but of steel, under the same conditions as above described, obtaining very good results; but before publishing them we desire to carry them further.

While the experiments with partially charged shell demonstrated that our sytem of gun-cotton shell charges is safe in firing, those with completely charged shell showed that the fuse arrangement functioned very well, and that the charge was always completely detonated. Partial explosions of the charge did not appear when using granulated gun-cotton. The form of gun-cotton which we prefer for charging shells differs materially from the ordinary disc form heretofore used.

A shell charged with gun-cotton in disc form is minutely described in Lieutenant-General Brialmont's "La Fortification du Temps Présent." The disc is not an advantageous form for gun-cotton to fill shell, as the projectile has to be made with movable head or base. We therefore also manufacture a granulated form, such that it can be put in the shell through the fuse-hole. Each grain has a sp. g. of over 1. The gravimetric density is .7. 700 g. (dry weight) fill a space of 1000 cbcm. The grains are rectangular, 8 to 12 mm. across, and either cubes or rectangles. They are gelatinized, thereby receiving a firm form and being protected against dusting. After the shell is charged with the grains, melted paraffine is poured in, which upon cooling cements them together and to the walls of the shell, forming a solid mass. For the larger shell, the principal part of the charge is composed of wet grains, to which are added about 200 g. dry grains, or enough to fill the shell. In using granulated nitrated cellulose for loading shells there will often occur partial explosions, burning or blowing away of part of the charge. Gun-cotton and other nitrated cellulose are more difficult to detonate than is generally supposed. We made the following experiments:

In a strong, tin-lined wooden box there was rammed wet uncompressed gun-cotton containing 30 per cent. of moisture, as hard as

could be without the aid of mechanical appliances; the box had ½ cbm. capacity, and contained 50 pounds gun-cotton, dry weight. A piece of compressed gun-cotton weighing 500 g. was placed in the middle of this box and detonated, whereupon the box and its contents were torn to pieces and scattered in every direction, without causing even partial explosion or burning of the wet uncompressed cotton. A heap of similar cotton was laid on the ground, on top of which were placed 250 g. of compressed cotton and detonated. Again there was no explosion of the uncompressed cotton, though it could not escape the blow of the detonation.

Wet uncompressed gun-cotton is then to be considered as a non-explosive material. The transportation thereof in one of its lower orders, collodion-cotton, is permitted by the railways. There would be no danger to railway traffic if wet compressed gun-cotton were permitted to be transported under the same conditions as collodion-cotton, as, in relation to the incidents and accidents of transportation, it may be considered as collodion-cotton, while for use as an explosive it is much more advantageous. To carry this idea into practice it would be necessary to lower the prescribed percentage of moisture to 25 per cent. for compressed gun-cotton, instead of 50 per cent., as in collodion-cotton, as the former will not absorb 50 per cent. Gun-cotton containing 25 per cent. of moisture is an article which, under all circumstances of possible railway accidents, could not be exploded.

In store, at the point of utilization, the wet gun-cotton will become dry if not moistened when needful, and so become sensitive to detonation by a detonator.

If the transportation of wet compressed gun-cotton were free, it would be possible to supply to small consumers a high explosive. A material service would thus be rendered to rural economy, where a high explosive would be of great use in road-building and clearing land, as in blasting rock and breaking up stumps and roots.

Dry uncompressed gun-cotton burns fiercely, may explode, but does not detonate; it can be used as gunpowder. The conditions of granulated gun-cotton are similar. It naturally does not offer great resistance to the blow of the priming charge; nor is great resistance to be expected from part of a granulated charge against the action of another part which has been detonated by the priming charge. Gun-cotton is itself difficult to detonate if not in large, heavy pieces; it yields as it receives the blow of the priming charge, and is only

ignited or blown away. The finer the powder, the smaller and lighter the grains, the greater the inclination of the gun-cotton to burning or partial detonation, and therefore the priming charge must be large and the confinement great to realize complete detonation.

It is highly probable that it is not possible to detonate considerable quantities of most sorts of granulated nitrated cellulose in any practicable manner. With the granulated gun-cotton manufactured by us at Walsrode it is different. In the first place, the grains are not immoderately porous or light: they have the same composition as the larger masses of compressed gun-cotton. In the second place, the grains are not very small: 6 mm^3 is the minimum size; we preferably make them of the maximum size, 1 mm. thick by 25 mm. long, as it is easier to manufacture the larger sort. In the third place, the paraffine which we pour into the shell after charging it forms with the grains a compact mass, which acts as a piece of compressed gun-cotton. Generally a 1 g. fulminate-of-mercury detonator was sufficient to detonate this mass when the grains were dry; if they were wet or paraffined, then a proportionally large priming charge had to be provided.

While in the case of a shell charged with wet granulated gun-cotton, the charge cemented in the shell with paraffine, a priming charge of 35 g. is ample, it would be insufficient in the case of a similar charge wholly paraffined. In the latter case there would be required so large a priming charge that it would be difficult or impossible to find room for it. If a 65 g. priming charge is not sufficient to produce detonation, then will one of 100 g. be insufficient, though in the course of the experiments it once proved sufficient. On the contrary, there will result partial detonations and burning. Moreover, paraffining enlarges the grains and so reduces the gravimetric density of gun-cotton.

These reasons, combined with the loss of chemical stability in paraffined grains, seem to make their employment altogether inadvisable.

In the case of the wet and dry granulated gun-cotton made by us and united in one mass by paraffine, there is no danger of partial detonations. In case of slight confinement even, as in a light tin case, the gun-cotton is readily detonated, as the experiments show, and as follows from the nature of the case.

It is not possible to avoid a loss in weight of the explosive when

granulated instead of compressed gun-cotton is used, the sp. gr. being the same in each. Our experiments have shown, however, that the difference in destructive effect is not very marked. And in this connection it is in favor of the granulated gun-cotton that its shell, being in one piece, is stronger than the one made to be charged with compressed gun-cotton, which would have to be in two pieces. If not too great a demand is made on the strength of the shell, the sides of steel shell can be made thinner, and, in case of cast-iron ones, they may be lengthened, thus increasing the capacity for the explosive charge. Cast iron may still be considered as an acceptable material for shell in one piece. Thus may be secured a remarkably effective shell, yet a cheap one. Economy appears likely to become the only means of bringing gun-cotton shells to their greatest possible and, as it appears to us, necessary development, notwithstanding their always limited sphere of action. Granulated gun-cotton has the further advantage of furnishing a uniform explosive material for charging shell of all calibres and kinds. It is not necessary to enlarge upon the advantage this material has for the purpose over compressed gun-cotton, which would have to be provided of different sizes for different shell. The effort for uniformity in ammunition is well known, and shown to be necessary. Moreover, the use of this material will enable the whole stock on hand of cast-iron and steel shell to be converted into gun-cotton shell, thus not only securing for them a more powerful explosive effect, but also increasing greatly the number of fragments upon explosion, so that their effect must prove exceptionally great.

It is known that by casting a number of light bulkheads in the shell, and again by providing the shrapnel, the number of fragments realized from projectiles was greatly increased. The first method could only be applied to a limited class of shell, and so an increase of resulting fragments from shell generally is a great consideration. The second method has the disadvantage of creating a separate and peculiar kind of projectile, and it is admitted that shrapnel would be gladly dropped if an equivalent could be had in shell. The cast-iron shell charged with granulated gun-cotton is destined to realize great advantages in this direction, at least for use in fortification and siege artillery. It is hardly probable that gun-cotton shell will be introduced for field artillery.

The following experiments give an idea of the number of fragments to be realized from ordinary shell:

In a specially built compartment, walled in, well closed, lined with boards, and provided with an outlet for the gases, to moderate the effect of the most violent explosions, we exploded, and realized from an 8.8 cm. cast-iron shell weighing 7 kg. and charged with ordinary cannon powder 37 fragments, weighing altogether 6160 g. The same shell charged with granulated gun-cotton yielded 200 fragments each more than 10 g. heavy, and 600 fragments between 1 and 10 g. heavy. From an 8.8 cm. steel shell 6640 g. heavy and charged with granulated gun-cotton we realized 23 fragments of total weight 2260 g., and 127 fragments of total weight 2865 g., or 150 fragments of total weight 5125 g. From a cast-iron 15 cm. shell weighing 27 kg. and charged with ordinary cannon powder we realized 42 fragments. From the same shell charged with granulated gun-cotton we realized 376 fragments, each over 10 g. heavy, and 828 fragments, each from 1 to 10 g. heavy. A considerable part of a cast-iron shell is broken into minute fragments. In our examination we did not consider fragments of less than 1 g., though they deserve consideration, as most of them, through only the force derived from the explosion, were driven through boards 25 mm. thick; so that with them, in actual practice against troops, a considerable effect would be realized. Of fragments over 10 g.—which would receive velocity enough from the force of explosion to be effective at considerable distances—there were produced by the granulated gun-cotton charge nine times as many as by the powder charge; certainly an important result.

A peculiar characteristic of gun-cotton shell is, that unless provided with a retarded fuse they will explode upon impact, not an appreciable time after, as powder shell. In illustration of this we made the following experiments:

(*a*). Two targets ½ m. apart, and one behind the other, made of boards 40 mm. thick, were fired at with a gun-cotton shell, which went through the first, and exploded between the two.

(*b*). A target of boards 4 m. square was fired at with an 8.8 cm. cast-iron gun-cotton shell so that the shell struck the ground 2 m. in front of it. The shell exploded in front of the target, and the latter was penetrated by 135 fragments of the former.

(*c*). Two targets as in (*a*), but 2 m. apart, were fired at with an 8.8 cm. powder shell in such way that the centre of the target was struck. The shell went through both targets and exploded in an earth-bank beyond the second.

The powder shell was fused with the same percussion fuse as were the gun-cotton shells; the later explosion of the former cannot therefore be attributed to the fuse, as has heretofore been done, but must be due to the slower development of the powder gases as compared with the development of the gases from gun-cotton.

The characteristic of the gun-cotton shell, of exploding upon impact, must in many cases give it great advantage over the powder shell, as where objects are to be destroyed into which the shell cannot penetrate, as armor-plating or very strong masonry, struck at a small angle, from which the shell is deflected, and, if charged with powder, will be so late in exploding as to produce no effect; or again, in case of targets easily penetrated, when the powder shell will explode too late and beyond, as in trying to destroy ordnance stores and transportation trains.

By means of an interposed retardation in the fuse, through which detonation of the detonator is prevented upon impact, or by the use of a time fuse, the explosion of the gun-cotton shell may be regulated at pleasure. This retardation will be necessary in the bombarding of fortifications covered with earth, so that the latter may be penetrated before the shell explodes.

From the publications of the cast-steel works of F. Krupp in regard to their ordnance and firing experiments we copy the following paragraphs, as they appear to us to indicate where gun-cotton shell might be advantageously employed:

"Ordnance:—15cm. cannon 35 calibres in length.

"Projectiles:—

Kind of Projectile.	Length of Projectile.		Total weight in kg.	Weight of shell-charge in kg.
	Mm.	Calibre.		
Steel armor shell.....	500	3.35	51	1.5
Ordinary cast-iron shell.....	596	4	51	3.4
Ordinary cast-steel shell.....	670	4.5	51	6.2

"The mortar is intended for a different class of attack and defense than is the cannon, and the projectile therefor should be constructed with regard to this difference of object. In general the walls of a mortar shell may be made much thinner than those of cannon shell, as the gas pressures upon them in the bore are about in the ratio 1 : 2. The mortar is intended for firing at great elevations. Its objects are (1) to destroy earthworks; (2) to reach troops behind cover; (3) to break down cover.

"(1). For destroying earthworks, shell are necessary which have great penetration before explosion, take a large charge, and are strong enough to compel the complete conversion of powder into gas.

"It is necessary to fire at great elevations, and to use retarded percussion fuses. Cast-iron shell are not well adapted for this purpose, as they must have thick walls, consequently taking smaller charges; and again, they do not offer sufficient resistance to the developed gases, explosion resulting before all the powder of the filling charge is burned. Much more effective in this direction are steel shell, as they are free from the indicated faults.

"In case of firing with reduced charges, the thickness of wall of the steel shell may be very much reduced. To attain the normal weight it is then permissible to lengthen the shell. In this way shell with capacity for large explosive charges are obtained, and we have the so-called torpedo shell.

"(2). To reach troops behind cover, shrapnel is employed.

"(3). To break down cover. While for the destruction of earthworks it is necessary to retard the action of the percussion fuse, to secure great penetration before explosion, for breaking down cover it is desirable to secure explosion upon impact; otherwise the shell will explode on the rise after impact, causing the loss of the explosive effect on the cover. As is known, it has not yet been possible to remedy this fault, nor is it probable that it will be done, as even with the most sensitive fuses a certain time elapses from the impact to the explosion of the shell; and from the nature of the case this must occur so. It is necessary to strive for the shortening of this interval as much as possible."

From these extracts we perceive that the armor shell has capacity for only a small charge; and in the case of the larger calibres of steel armor shell, fired with brown powder at an initial velocity of 500 m. or more, an ever so powerful shell charge would not materially increase the effect of the projectile, though it would do so to some extent, as it would at least clear the hole made by it.

The cast-iron and cast-steel shell have capacity for explosive charges sufficiently large to produce marked effects.

The steel torpedo shell is the most suitable form of projectile for the employment of gun-cotton charges.

For the destruction of earthworks the gun-cotton shell is of great importance, as it produces greater effect in earth than the powder shell. Retarding the action of the fuse is easily attained.

For breaking down cover the gun-cotton shell is indispensable, as only it realizes the desired object of explosion upon impact, which can never be attained with the powder shell, as the slowness of its explosion is inherent in the powder, and not due to the fuse, as our experiments have shown.

The cast-iron shell will be much improved if charged with gun-cotton, for the comparatively weak confinement it affords to the explosive charge, and the reduction of the same on account of the great thickness of the walls, are more than counterbalanced by the quicker and stronger action of gun-cotton over powder. A steel shell with thin walls is always, however, preferable.

In regard to shrapnel, we note that it is probable that they may be wholly superseded by cast-iron gun-cotton shell, as our experiments have demonstrated that the latter yield as considerable a number of fragments upon explosion as do the former. We repeat that the common 15 cm. cast-iron shell, charged with gun-cotton, yielded upon explosion 376 fragments, each over 10 g. heavy, and 823 fragments, each between 1 and 10 g. heavy.

We hope that Mr. F. Krupp, with the great facilities which his establishment offers, will soon enter upon experiments with gun-cotton shell, as it is evident that they are at least calculated to supply a remedy for many important deficiencies in the effect of projectiles. If with a changed trajectory they offer advantages in the premises, as we saw in mentioning their characteristic of explosion upon impact, then is the question of a more powerful explosive than powder for charging shell of the greatest importance, though not of equal importance for all shell, and it must be decided in the near future. Should Mr. Krupp take hold of these experiments, we are convinced that he would carry them to a satisfactory conclusion in the brilliant manner in which he has so far solved all ordnance problems. If we could be of any assistance in the premises, with our gun-cotton factory, and with our experience of years in explosives, we would always be at his disposition.

Interesting paragraphs in regard to the employment of gun-cotton shell are found in Major Schumann's work upon armored turrets, and indeed he says: "In England there has been adopted for coast fortifications plating upon the so-called sandwich system, a combination of three to five plates of from 15 to 16 cm. thickness, with wood between.

"It may be expected that with the latest and materially improved

steel shell, penetration enough will be secured so that, charged with a high explosive, upon explosion a very destructive effect will be realized upon the whole system. The penetration of the projectiles in the massive rolled iron armor of 40 to 60 cm. thickness will naturally be much less. In case the plates are soft, and so not easily cracked, there may be expected considerable effect from shell charged with high explosive, and which strike at or near the edges of the plates. The two latest improvements in shell support each other here.

"The Krupp shell, made of the very best material, forged with a hammer upon a former, receive by this method of manufacture a degree of strength and toughness which enables them to withstand breaking up better than solid shot. Withal, the tempering is so perfect that, for example, a shell fired from a 15 cm. gun 35 calibres long went through two 18 cm. plates and 25 cm. of wood between them, and the only effect upon it was to grind the point down 1 mm.

"The second improvement consists in utilizing high explosives for charging shell whose hardness and toughness admit their penetrating far enough into soft, vertical rolled iron plates to at least make effective a part of the high-explosive charge. Where, then, such armor can be struck with sufficient velocity to give these shells necessary penetration to utilize the force of their high-explosive charges, it will be necessary to find means to obviate this penetration.

"Armored targets to be directly attacked are (*a*) armored ships, (*b*) armored coast fortifications, and (*c*) armored turrets occurring in the general system of fortifications of a country.

"The object of the Schumann system of construction is to protect the armored turrets of a general system of fortification against the direct fire of armor shell out of long guns. This is done by building the turrets in the form of an umbrella, upon which the shells cannot strike perpendicularly. They will strike at an acute angle and be deflected without having produced any effect. The explosive effect of the shell would be the only thing to do damage, but it will not act in time, as the shell will explode too late, whether charged with powder or gun-cotton."

From these deductions of Major Schumann, it appears that he expects to realize material results from the use of high explosives as charges for armor shell, and we take occasion to note what follows in relation to the technical construction of the shell:

If the shell which penetrates the armor is charged with gun-cot-

ton, and this is detonated by the shock of the shell against the armor, and indeed without the action of the priming charge and detonator—we do not doubt that the dry priming charge is ignited or exploded; the question is, whether it detonates so as to detonate the wet gun-cotton—then it will detonate before the shell has exerted its full force, or too early. The development of the gases from the detonation of gun-cotton, as compared with their development from the explosion of powder, is instantaneous, as we have observed and reported, and this will be so whether detonation results from the action of the detonator or the shock of impact.

A fuse, even a retarded one, in a shell which strikes armor at right angles and penetrates it will not withstand the shock—it will break up—and therefore no result can be expected in delaying the explosion through retardation of the fuse. If dry gun-cotton, therefore, is detonated by the shock of impact, then the shell will explode too soon; if, however, it does not detonate, but simply ignites, it would be possible, by disposing of the detonator in the shell in such a way that it will not be detonated by the shock of the powder gases against it in the bore, and thus cause premature explosion, to retard the explosion of the shell; and, indeed, the action within the shell would probably be as follows: The detonator would be detonated by the burning dry gun-cotton, and would detonate such portion of the dry gun-cotton as remained unconsumed. It will not occur that there is no dry gun-cotton left for the detonator to act on. By way of experiment, the above conditions may be realized by taking a piece of dry gun-cotton which has a hole in it to receive the detonator, placing one therein, and setting fire to the gun-cotton at some point and observing the result. In a great number of these experiments which we personally made, the gun-cotton was always detonated by the ignition and burning thereof, supplemented by the detonation of the detonator.

We have demonstrated that the same thing occurs in shell. We believe, further, that, suitably constructed and properly located, the detonator will be more difficult to detonate by shock than it is to ignite dry gun-cotton by the same means. Again, it is not to be feared that after the dry gun-cotton has begun to burn, the shell will explode before the detonator is detonated. It is consequently quite possible that an armor shell charged with wet and dry gun-cotton, and provided with a detonator, but no fuse, may explode at the right time, that is, not too soon, as the development of the flame in the

dry gun-cotton and carrying the same to the detonator consume a certain time. We are not aware that this has been demonstrated by experiment, but, on the other hand, it is quite evident that the circumstances will be much more favorable in the case of a shell which cannot, and should not, penetrate the armor. These shell will have the greatest possible explosive charge, and be provided with a fuse, naturally not a retarded one. Either the shell strikes the armor at an acute angle and is deflected, and it will upon striking, notwithstanding Major Schumann's opinion to the contrary, explode in a favorable position, being in contact with the armor its whole length, or it strikes at right angles, so that it breaks to pieces or is flattened. In either case it will explode at the right time to act with the whole explosive charge, as it will explode upon impact. We believe, therefore, that the Schumann armored constructions are not protected against the action of gun-cotton shell as they are against that of powder shell, and that gun-cotton shell will be of great service against armored constructions of all kinds.

The object of our experiments with gun-cotton shell has been to demonstrate that the ordinary shell may be converted into a gun-cotton shell very readily by means of an arrangement provided by us, and fired at great range from ordinary cannon, mortars and other ordnance, by means of the heretofore-employed powder; and to demonstrate the advantage thereof as compared with a proposed dynamite shell, to be propelled by compressed air from a peculiarly constructed gun, and as compared with many other proposed and some existing methods of throwing shell charged with high explosives; in all of which is necessary extraordinary apparatus, difficult of transportation, complicated in structure, and of great expense. We lay great stress upon the simplicity there is in the use of our gun-cotton shell, and feel in duty bound to express our opinion that, for throwing projectiles from guns, there should never be used anything but the compactest and cheapest power-developing agent, as gun-powder.

Our contrivances have reference only to the charging of heretofore ordinarily employed shell with gun-cotton. There is no change of material in any part, except in the explosive charge; even the weight of the gun-cotton-charged shell is the same as heretofore. These valuable results have been attained by us (1) through the manufacture of a new, peculiar, and suitable form of gun-cotton; (2) through a special arrangement in charging the shell, that is, filling them up

afterward with melted paraffine; (3) through constructing a suitable fuse.

We are convinced that gun-cotton shell will perform much important service, even if they do not work wonders.

The effect of high explosives is overrated; for example, upon a small area of armor no high explosive will produce nearly so much effect as will be produced by a steel shell from a 30 or 40 cm. cannon. However, there are but few such guns, and it is not possible to move them about to any extent. In field and siege operations the increase of effect through increase in calibre of gun soon reaches its limit; it is doubtful if there is any way to secure increased effect except by increasing the explosive effect of shell. We believe that shell charged with high explosives are to play a great part in the future, even though they do not accomplish as much as is unreasonably expected from them. For the very reason that they will not work wonders, it is our further opinion that the high explosives must be so adapted to them that they may be employed in the ordnance as it exists.

We give these lines to the kindly-disposed reader with the assurance that, while we have often spoken *pro domo*, yet it has been our effort to carry on the experiments impartially, and to draw the conclusions from them in the same spirit.

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NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XII.

In the *Phil. Mag.* **21**, 164–180; March, 1866, R. Threlfall published at length the results of his investigations "On the Theory of Explosions." † In his papers on the action of detonators, Sir Frederick Abel ‡ described some curious experiments, which he strove to account for by an hypothesis of "synchronous vibrations." § This hypothesis has been treated of at length by Berthelot, ‖ and although much light, both experimental and theoretical, has been thrown on the matter by Vieille and Berthelot, the explanations offered by the latter do not seem altogether satisfactory to Mr. Threlfall, and he has concluded that something of interest might be gathered from a study of the behavior of the products of explosion, especially as regards the manner in which they escape from the centre at which the explosion takes place. Much might be learned from a measurement of the velocity of transmission of a shock to points at small distances from the centre of explosion. This would be merely a question of apparatus, and Lord Rayleigh suggested the use of a sensitive flame and revolving mirror, which would, at all events, give some idea of the sort of disturbance experienced; but Threlfall deemed it best to

*As it is proposed to continue these "Notes" from time to time, authors, publishers and manufacturers will do the writer a favor by sending him copies of their papers, publications or trade circulars.

† Proc. Nav. Inst. **12**, 197; 1886.

‡ Phil. Trans. **159**, 489; 1869.

§ Proc. Nav. Inst. **4**, 31; 1877.

‖ Proc. Nav. Inst. **10**, 206; 1884.

begin by examining cases where the results of explosion could be seen and watched.

For this purpose he constructed a tank measuring a yard each way, and provided with windows in the sides. The tank was filled with water, and water-tight glass bulbs of ½ inch diameter, filled with mercuric fulminate, were sunk to a depth of 18 inches in the water, fired by electricity, and the course of the *débris* from the explosion noted. As the torpedo was suspended vertically, this *débris* had the appearance of being shot down to the bottom of the tank—not in a jet, as might have been expected, but with exactly the rolling motion that smoke has in coming out of a chimney—as if, in fact, there was vortex motion of some sort. The constancy of the downward action of the explosion suggested that it was due to the want of symmetry introduced by the neck and wires of the torpedo. Hence experiments were made in which the torpedoes were placed horizontally, and then the *débris* seemed to move, with its peculiar rolling motion, horizontally away from the neck. In fact, the appearance presented to the unaided eye was that of a more or less definite column of rolling white smoke shot out with great velocity, and coming to rest very rapidly when about five inches from the centre, as if acted upon by an irresistible force. Experiments were also made by exploding a charge in the centre of a Florence oil-flask filled with red dye and immersed in the water. The dye was shot out with the *débris*, and the flash appeared to be suddenly stopped some two or three inches outside where the flask would have been if it had not disappeared. There were, however, so many sources of misinterpretation to be feared in this method of observation that it was not continued, but the experimenter contented himself with noting the peculiar rolling and the dead-beat motion of the dye as it was shot out.

Experiments were now made to determine if the directions of projection of the *débris* coincided with the directions of propagation of the streams of explosive energy. For this purpose two forms of gauges were devised. The first consisted of a short, stout brass cylinder, closed at one end with a brass cap, and at the other by a diaphragm of thin sheet-rubber. To a hole in the side of the cylinder a smaller brass tube was fitted, and this was attached to a glass tube. The apparatus was then filled with colored water, and, of course, when held vertically, any pressure on the rubber caused the water in the gauge to rise in the tube. Two such gauges were made, and then were firmly fastened to the two adjacent sides of the tank,

the centres of the rubber faces being as nearly as possible in the same planes with the torpedo. Explosion caused these gauges to register, but they were not uniform in action, and were difficult to read, so they were abandoned for a gauge in which a piston moved in the horizontal brass cylinder, and the piston-rod abutted on the bob of a lever pendulum. To the other end of the pendulum a long, light index was attached. By firing some dozen torpedoes arranged as symmetrically as possible, he found that the indications of the latter gauges were nearly proportional. Explosions were then produced in torpedoes purposely made unsymmetrical, either by having the glass too thick on one side, or by turning up the ends of the covered conducting wires so that they entered the bulb horizontally and facing one of the gauges. The effects now became more puzzling, but on the whole there can be no question that the gauge towards which the bulb was turned suffered most. In fact, the direction taken by the streams of explosive energy appeared to coincide with the directions of projection of *débris*, and with the direction foretold from the initial conditions.

The experiments were repeated at various distances and in various manners with more or less compressed charges, and with variations in the position of the firing-point. The pendulum readings were on the whole certainly proportional to the direction of explosion as foretold from the initial conditions. Of course in some few cases there were unexpected actions on the gauges; but this was hardly avoidable, since the previous experiments had shown how small a change in initial conditions could lead to great variations in the result. The position of the firing-point was the least satisfactory part of the experiments; most of the failures could be traced to imperfect centring of the firing-point; about ten per cent. of the experiments failed to travel on the paths laid out for them. These experiments leave little doubt that the direction in which the maximum explosive effect is transmitted will in a great measure depend on the initial arrangement of surrounding obstacles;* at all events, when the explosion is caused by fulminate of mercury and small charges are used.

The shock of an explosion must be transmitted in one or more of three different ways:

I. By actual bodily motion of the products of explosion through the surrounding medium, either alone or becoming more and more mixed up with the medium itself, which is thereby set in motion.

* Proc. Nav. Inst. **9**, 735; 1883.

II. By an undulatory motion set up in the medium.

III. By vortex-ring motion.

In the explosion of gunpowder and other slow explosives the energy is transmitted chiefly by I and II. The distance to which a considerable quantity of the energy may be conveyed by means of waves of comparatively great amplitude is in some cases remarkably great. This is evidenced by the effects produced by the explosion of powder magazines.

In the case of the fulminates of mercury and silver, gun-cotton and nitroglycerine—that is, explosives of the class examined under water—the effect falls off very rapidly with the distance, and in water, at all events, is of a directed character. This would point to the third mode of transmission being in these cases of some importance; and if we consider the way in which the products of explosion escape, we shall find that the conditions for the production of vortex motion do in fact exist. Let there be a sphere of fulminate of mercury fired from its geometrical centre. Then, by Vieille's* experiments on the time of explosion, it seems likely that the outer portions of fulminate will be decomposed before they are removed to any appreciable distance from their original positions. We shall therefore have a sudden expansion in all directions, caused by the increase in volume of the explosive substance during the explosion. There seems no reason, under perfectly symmetrical conditions, why the expansion should not go on as it began until the cooling of the sphere of hot gases becomes so marked as to prevent further expansion.

If the conditions, however, are not such as to allow of symmetrical expansion—as always occurs in practice—then we shall have the bounding surface of the explosion gases more curved in some places than in others; that is, the strain will be greater at some parts than at others, and in fact may become so great at points of great curvature as to lead to a state of "breakdown." In other words, the compressed gases will in this case escape, not by gradual expansion, but by jets, from points whose position is fixed by the conditions of explosion. In these jets we should have the necessary and sufficient conditions for the establishment of vortex motion. If vortex motion were set up, then it seems likely that much greater effects might be transmitted in some directions than in others, though at considerable distances the effects would tend to become uniform in all directions. The author believes that this view of the actions of explosions will enable

* Compt. Rend. 1882 and 1883.

us to explain several difficulties occurring in the interpretation of Abel's experiments. Among these are: The want of correspondence between the explosive actions, as measured by the effect produced on copper plates, and the effects produced in causing other explosions; the apparent capriciousness of explosions of the more violent kinds; the production of explosions by influence.

In his discussion of explosions, Berthelot has not added anything to the generally accepted theory that the explosion of gunpowder differs in no way from ordinary combustion, except that it is more rapid. His theory of detonation, however, is novel, and it may be summed up as follows: The kinetic energy of the shock of the explosion (by the detonator) is transformed into heat at the point struck; the temperature of this point is thus raised to the temperature of explosion; a new shock is produced which raises the temperature of the neighboring portions to the same degree; they then explode, and the action is thus propagated with an ever-increasing velocity.

Many experiments tend to show the justness of this view. To begin with, Abel found that almost any variety of effect could be obtained by burning explosives under diminished pressure. For, the lower the pressure, the more easily do the products of decomposition escape and carry with them the energy due to their liberation. By this means the temperature of explosion is constantly kept down, and the chemical character of the products modified in such a way that they correspond to the temperature. In other words, the compounds liberated are, as a rule, more complex than those which would be set free at a higher temperature, and therefore the energy run down is less.

Again, it will come to the same thing, so far as the propagation of an explosion is concerned, whether the products of decomposition are facilitated in their escape by conducting the experiment in a partial vacuum, or whether the decomposition is itself so slow that the products are enabled to escape without marked hindrance under ordinary pressure. Now, the resistance of the air to the escape of the products of combustion will depend on the rate at which they are liberated. And the shock given to neighboring portions of the explosive will be proportional to the pressure of the explosion gases at these points, and therefore ultimately to the resistance of the air, and hence to some function of the velocity of decomposition. But, in order to convert an explosion by combustion into an explosion by detonation, what is required is that the temperature of any point shall be raised

sufficiently to determine its complete, as distinguished from its incomplete, decomposition. The raising of the temperature of any point, however, will depend on the violence of the shock to which it is subjected; and this, as before stated, will be proportional to some function of the velocity of the decomposition producing it. If the necessary temperature is anywhere attained, we shall have detonation thereafter; if not, an explosion by combustion will result. It appears, therefore, that in order to produce a detonation, we require the initial velocity of decomposition to rise above a certain minimum value—that there is, in fact, a "critical velocity" of initial decomposition determining the kind of reaction which ultimately takes place. If the temperature of the whole mass be previously raised, then the critical velocity will become less. Berthelot considers that a specific change takes place in the stability of an explosive as its temperature is raised. This is doubtless true; but if a minimum temperature of any part be the necessary and sufficient condition for the production of a detonation, then the ease with which it can be obtained, when the mass starts with a high temperature, will, *cæteris paribus*, be greater than if the original temperature is low. If, therefore, we find that nitroglycerine is more liable to detonation the higher its initial temperature, we shall not be required to make any assumption as to "increased sensitiveness," since we see that the minimum temperature will be more easily reached, and that therefore the critical velocity of initial decomposition may be smaller. In other words, supposing we try to detonate nitroglycerine by an explosive which just fails at ordinary temperatures, we should expect its chances of success to increase as the temperature rises; and this does, in fact, occur.

The sensitiveness of an explosive to detonation has been found to depend on its state of aggregation. The critical velocity required to produce detonation will, *cæteris paribus*, depend on the nature and value of the elastic constants of the explosive, as well as of the medium in which it is to be exploded. We should, in fact, expect a change in the critical velocity of detonation if we exchanged the viscous resistance of liquid nitroglycerine for the elastic resistance of the same substance when frozen. Again, it seems possible, as a result of this theory, that less powerful detonation might be required to explode a given substance in water than in air; but the author is not aware of any experiments on this point. And so in other cases, though the critical velocity of detonation must necessarily be a very

complex function, and difficult to predict; yet there appears to be no reason on that account to minimize its importance. On the other hand, it seems to the author to be in complete harmony with Abel's experiments, and substantially embodies the views set forth by Dixon,* and the author knows of not a single experiment which offers any evidence against it. What is required by the theory for the production of a detonation is that a small part of the mass should be raised above a given temperature, and not that a large portion should be raised to a temperature below it.

This leads at once to the consideration of the second point—viz.: the action of detonators. The apparently anomalous effects discovered by Abel may be summed up by taking the most extreme case. Gun-cotton could be detonated by a charge of fulminate of mercury, whereas ten times as much nitroglycerine was required to cause a similar sample of gun-cotton to detonate. By firing the detonating charges on copper plates, Abel naturally observed that the destruction produced by the nitroglycerine was much the greater, and hence concluded that some other factor besides the "explosive violence" must come into play. This is undoubtedly true, but the mistake arises in looking at the experiments from one point of view alone—viz.: that of the copper plate. There will be no effect produced on the plate at all till the resistance of the air becomes greater than that of the plate; and this will never be the case, however great the volume of gas liberated, unless the time of explosion be sufficiently short. The resistance of the air varies at least as the square of the velocity of attack, and therefore this will be the conditioning factor of the destructive effect producible by explosions in free air. For a given increment of volume occurring in an explosion, till the time of explosion diminishes to a certain value depending on the strength of the plate, no effect will be observed; directly this limit is passed, the destructive effects will depend in the usual manner on the quantity of energy liberated. There is, in fact, a critical velocity of explosion below which the plate will not be attacked. But in a detonation the case is different. We do not require any great destructive effects: we only require that the time should be so short that a portion, no matter how small, of the substance to be detonated should be raised to the appropriate temperature. If the detonator has a time of explosion too great, then, although the air may be the stronger obstacle and the explosive destroyed, no detonation will be

*On Conditions of Chemical Change in Gases, *Phil. Trans.* 1884.

produced. This is precisely what happened in Abel's experiments, when the gun-cotton was blown to pieces by the nitroglycerine. The instantaneous rise of pressure is not so great for nitroglycerine as for fulminate of mercury, though the energy run down is much greater. This point has been satisfactorily proved by Vieille in his experiments with the crusher gauge. Moreover, the density of mercury fulminate is three times that of nitroglycerine, which allows a given mass to be on the whole much nearer its work if it consist of fulminate of mercury, than if it consist of nitroglycerine.

We ought not therefore to be surprised that the detonation of gun-cotton is easily accomplished by fulminate of mercury, and hardly accomplished by nitroglycerine. If there is any surprise, it would seem more fitting that it should be exhibited at the detonation which large charges of nitroglycerine seem able to effect.

This fact would tend to show merely that nitroglycerine has a velocity very near the critical point for gun-cotton—so much so, that when large charges are employed the acceleration in the explosion of the nitroglycerine is sufficient to pass the limit. We know from Dixon's work on gases that at first the explosion gains in velocity till the steady velocity of detonation is obtained, and there seems no reason against, but, on the other hand, every probability in favor of, the same thing taking place in nitroglycerine.

Above and beyond this, the difference in the mode of application of the two detonators must be taken into account. In Abel's experiment the fulminate was enclosed in a tube of copper or tin plate, while the nitroglycerine was merely applied in a capsule whose diameter was large compared with its depth. The upper end of the fulminate tube was probably closed by the electric firing-apparatus; and this, as was shown by the experiments in water already described, together with the fact that the fulminate was fired at the top, would give it an enormous advantage. For there is considerable probability that in explosions of high velocity in air, the final mode of "breakdown" of the gas liberated is very dependent on the initial conditions, just as it is shown to be in water. The nitroglycerine was deprived by Abel of these advantages; and for these and the reasons above mentioned, though it was able to blow blocks of compressed gun-cotton into powder, and even to cause some of this powder to penetrate the hard wood of the support, it failed to cause detonation.

The other apparently anomalous facts observed by Abel require further treatment, and most of all those explosions by influence, which

seem at first sight only explicable by some theory such as that of synchronous vibrations, suggested by Abel himself. The difference in the behavior of nitroglycerine and fulminate of mercury, regarded as detonators, led Abel to suggest that there might be some synchronism between the vibrations caused in air or ether by the latter explosive, and the natural period of vibration of a gun-cotton molecule. At all events, the supposition is made that fulminate of mercury when exploded can produce vibrations which are not produced by explosions of nitroglycerine, and that the superior detonating power of fulminate of mercury may be due to the presence of these vibrations. The first set of experiments bearing on this point have been already discussed, with the result that the hypothesis is perhaps unnecessary. There are, however, a great number of other experiments, some of which cannot be so easily explained. In one case an explosion was induced in a charge of fulminate of silver placed at the end of a tube by the explosion of a similar charge at the other end. The effect was not interfered with by placing diaphragms across the tube; but the state of the internal surface of the tube seemed to exercise considerable influence. Experiments were also made on the action of fulminate of mercury on gun-cotton* through tubes. The great influence exerted on the detonating power by the smoothness or roughness of the walls of the tube seems a strong argument against the supposed synchronism having much to do with the effect in these cases. On the other hand, it is just what we should expect if there was bodily motion down the tube, or even if, as in the case where diaphragms were inserted, the motion was transmitted from layer to layer without any great amount of displacement in each individual particle. It seems possible that some vortex motion caused by the "breakdown" might be transmitted through the tube, and that the diaphragms merely served to change the portions of air of which the rings were actually composed. The author admits that this is not very satisfactory; but if the roughening of the internal surface of the tubes actually exerted the effect attributed to it, we are justified, in the author's opinion, in supposing that the explosions were not caused by the transmission of vibrations through the material of the pipe itself. Again, vibrations, to be of any effect in producing chemical change, must be comparable as to period with the molecular vibrations. If such vibrations are transmitted through ether, it is difficult to see where

* Proc. Roy. Soc. **22**, 160; 1874.

the influence of chalking the inside of the tubes can come in; and if through air, their wave-length would be too small (as will be shown) to be likely to be much influenced by particles of the size of chalk-dust.

The similar experiments of Champion and Pellet* are sufficiently explained by their statement that they used iodide of nitrogen. Unless any one likes to suppose that the period of a fiddle-string may be comparable with the period of an iodide-of-nitrogen molecule, the further experiments of Champion and Pellet cannot be held to have much bearing on the subject. One can only wonder that they found a string that would vibrate slowly enough not to fire their iodide. As to their experiments with mirrors, blackened or otherwise, the results obtained might be anticipated on almost any theory except that of "synchronous vibrations." For the vibrations supposed on this theory to be most active would be precisely those absorbable by lampblack. This point has been investigated by Berthelot in a manner which leaves little doubt that he misunderstood Abel's theory. In order to show the importance of vibrations in producing chemical change, Berthelot experimented on various chemicals by swinging them on tuning-forks. No effect was produced, nor indeed was it to be expected, unless the reagents were of such a nature that they required intense shaking to keep them mixed. Berthelot also experimented on ozone at much higher frequencies of vibration by causing a tube filled with the gas, mixed with oxygen, to be set into violent longitudinal vibration. No change in the ordinary rate of decomposition of ozone was observed. This is very interesting, but does not seem to touch Abel's theory. In order to disprove the theory, Berthelot ought to have made his tube vibrate till it got luminous, and observed the effect on the ozone all the way up.

There are many well-established cases of torpedoes exploding one another by influence, and the same thing occurs in firing dynamite shots in mines. The former alone possesses any interest for our present purpose. If the effects due to fulminate of mercury when fired under water are in any way similar to those which may be supposed to take place on the detonation of large charges of gun-cotton, then, by the experiments described above, it would be likely that quite extraordinary effects might be propagated in some cases. There ought, however, to be a capriciousness in the observed action of torpedoes on one another; whether this has been observed or not, the author is

* Compt. Rend. 75, 110.

unable to state, but he assumes that it has not, and that here we have a case where the effect is largely due to "synchronous vibration." He therefore considers the ways in which vibrations of sufficiently small period could be transmitted, first assuming that no vibrations can have any influence unless they are of such period as to be comparable with the natural period of vibration of the molecules of the substance to be exploded.

Let a body be gradually heated, and its temperature measured as soon as light comes from it having the same refrangibility as the line *A* in the solar spectrum. Let the temperature be, say, of the order of 1500° C. Then the molecules of the body will be vibrating in some way comparable with the period of the *A* line; that is, about 4×10^{14} times per second. Suppose gun-cotton could be heated red hot without decomposition; then its molecular period would be of this order. We are quite unable to say how the period varies with the temperature in solid bodies at low temperatures. But the spectroscope shows that it does not change much at high temperatures.

The only possible way of obtaining an idea would be to extend the spectroscopic investigation even further than it has been done by Abney; either photographically or by the thermopile. We will assume, however, that as the bodies cool, their molecular vibrations, if altering at all as to period, tend to become slower, as well as of smaller amplitude. Let us consider the limiting condition of propagation of waves of longitudinal displacement. There seems no reason for supposing that the velocity of propagation would fall off till we come to waves of wave-length comparable with molecular distances—for instance with the mean free path. Now, by experiments in diffusion, it seems that the mean free path in oxygen is of the order of 5.6×10^{-6} cm.; in sugar solution it is 10^{-5} of this, or 5.6×10^{-11} cm.; while in solids it is probably much less. The size of the molecule, however, seems to be of the order 5.8×10^{-8} cm., so this will give our superior limit in solids and liquids.

Suppose that the smallest possible wave-length is the diameter of a molecule, and that the velocity of propagation is the same as that of sound down to this limit. Then, if V be the velocity of propagation, or the number of vibrations per second, and λ the wave-length in water, we have

$$n=\frac{V}{\lambda}=\frac{1.4\times10^{5}}{5.8\times10^{-8}}=2.4\times10^{13}.$$

But it is unlikely that we could get a wave-length anything like so

small as this, so let us take as our limiting value the wave-length equal to a thousand molecular diameters. This gives us for the limiting frequency

$$n = 2.4 \times 10^{9}.$$

Comparing this with n for the A line, which is 4×10^{14}, we see that it is about a million times too slow to produce any effect on molecules vibrating so as to emit red light. But bodies at the ordinary temperature might possibly vibrate slowly enough to be influenced directly, though this is unlikely. It is rather surprising that the numbers are as comparable as they seem to be. If we perform the same operation for gases, putting $\lambda = 1000$ mean free paths, we get for oxygen $n = 5 \times 10^{6}$. Here the discrepancy is a thousand times as great; so that if longitudinal vibrations are to be considered as likely to produce any effect, they will be considerably more likely to do so if transmitted through solids or liquids than through gases.

We have still got the ether to fall back on, and there we are safe, for there is no reason why vibration of the right period should not be transmitted through it.

The experiments with tubes, however, seem to point exclusively to the air as the medium through which vibrations are to be transmitted, and that may be fairly regarded as unlikely. If the theory of synchronous vibrations can be disproved at all by experiment, then Abel has at all events made the most telling experiment against it; there may, of course, be other experiments, and these may point in the opposite dirction, but the author has failed to learn of them. Still, in the light of what has been published on the subject, there is little doubt that our natural hesitation to accept a theory of vibrations is justified by a consideration of the facts. On the other hand, if we admit that vortex motion may exist, it will account for some of the effects observed in the neighborhood of violent explosions. The most important effect to be accounted for is the capriciousness of explosions. Instances are so numerous that it is hardly worth while to dwell upon them in detail; but take the famous explosion at Bremerhaven, for instance, and it is curious to note the way in which the bystanders seemed actually singled out for injury, and that not always from flying *débris*. Such effects as these are difficult to account for on any theory of uniform propagation of wave-motion. On the other hand, any of the observed phenomena of propagation of explosion are as well explained by vortex propagation as by wave-motion. There is no reason why the two states of propagation should not exist together,

varying in their relative importance according as the explosion is of long or short duration. In ordinary cases of detonation, we may imagine the shocks to be given by the explosion gases before any considerable breakdown has taken place.

Raschig has studied the fulminating compound obtained by Berthelot nearly a hundred years ago by the action of ammonia upon silver oxide. For the preparation of the substance, a solution of silver nitrate was precipitated with sodium hydrate, and the silver oxide washed by decantation. For each grain of silver nitrate used, there were poured upon the silver oxide 2 cubic centimetres of an ammonia solution containing 25 per cent. of NH_3. The oxide of silver dissolved readily, leaving only a slight turbidity. The solution thus obtained was divided into several portions, each being placed in a porcelain dish about 10 cm. in diameter, so proportioned that no dish contained the oxide from more than one gram of the nitrate. Each dish was covered with a watch-glass and allowed to stand for 16 to 20 hours. The ammonia evaporated and the fulminating silver was deposited as a black, crystalline mass. After washing, it was analyzed by digestion with very dilute sulphuric acid, by which a residue of metallic silver was generally left. The dissolved silver was precipitated with hydrochloric acid, and in the filtrate the ammonia was determined as platino-chloride. The results of sixteen analyses gave ratios which were very close to three atoms of silver for one of nitrogen; leading to the formula NAg_3. Other samples of the substance, prepared by warming the ammonia solution of the silver oxide on the water bath, or by precipitating it with alcohol, gave the same ratio on analysis. It explodes by the slightest concussion when dry, and requires great caution in handling even when moist. It is soluble in ammonia and in potassium cyanide. (*Liebig's Ann.* **233**, 93–101, April, 1886; *Am. Jour. Sci.* (*abstr.*) **32** [3], 232, Sept., 1886.)

Isaac Friedenwald, Baltimore, Maryland, has published Part I of an "Index to the Literature of Explosives," prepared by Prof. Charles E. Munroe, U. S. N. A., which contains the titles of all papers relating to explosives or explosions which have appeared in *Am. Jour. Sci.* 1819–1886; *Phil. Trans. Roy. Soc.* 1665–1882; *Jour. Roy. U. S. Inst.* 1857–1885; *Proc. U. S. Nav. Inst.* 1874–1885; *Revue d'Artillerie*, 1871–1884; *H. M. Inspect. Explosives*, 1873–1885; making in all 442 separate publications. This index is intended to embrace not

only such articles as treat of the composition and of the chemical and physical properties of explosive substances, but also of their manufacture and use in the arts.

The *Army and Navy Gazette*, **27**, 801, October 9, 1886, gives the following glowing account of the new French mortar shell: It is stated that the French Budget Committee intend recommending £5,000,000 for new armaments, in consequence of the discovery of an explosive substance which necessitates serious changes. General Boulanger some time ago had his attention drawn to the fact that the Germans were manufacturing shells charged with *hellhofite*,* which had produced the most terrific effect on earthworks and masonry. Germany has already 175,000 of these shells in store. At the same time, the discovery of another explosive substance of equal if not of greater force than the German *hellhofite* was made in France (*mélinite*), the composition of which is kept a profound secret. At the first trial at Bourges, a gun charged with a *mélinite* shell burst, and caused fearful ravages. However, Lieutenant-Colonel Déjo, of the 3d Battalion of Fortress Artillery, has fired the new shell from a mortar, with similar results to those obtained in Germany. Neither walls nor earthworks nor plates can resist the force of this new agent. The shell is 40 inches long, about 8 inches in diameter, and weighs 220 pounds. General Boulanger got a deputation to accompany him to Soissons; one of the new shells was thrown into an old fort, and after explosion nothing of the fort remained. The committeemen were immediately convinced. One French writer, dwelling on the destructive quality of these shells, says that had they been used against Paris in 1870 by the Germans, or in 1871 against the Commune, the capital could not have resisted for a week. During the Commune, one house in the Avenue des Ternes was riddled by no fewer than 85 shells, and yet it did not fall. Now one of the new shells, we are assured, would destroy a whole block of houses. On the one hand, we are assured that *hellhofite* and *mélinite* have rendered all fortresses useless, and, on the other hand, we are informed that the profiles of all the new French forts are to be at once changed, so as to adapt them to the new order of things.

The *Jour. Mil. Service Inst.* **7**, 339–349, Sept., 1886, contains a rather rough translation by Major G. W. McKee, U. S. A., from the

* *Vide* Proc. Nav. Inst. **8**, 450; 1882, and **11**, 771; 1885.

Spanish of Adolfo Carrasco,* entitled "The Employment of Dynamite as a Bursting Charge for Artillery Projectiles." Mr. Carrasco details the composition and properties of dynamite, discusses its practical effects against armor, as shown by Folger's experiments, and considers its efficiency in projectiles, adopting the conditions set forth by us.† He then reviews the methods used and the results obtained in various experiments which have been made in firing projectiles charged with this agent, and after describing the dynamite air-gun and its use, he says: "Such an invention, neither by its arrangement, manipulation, nor effects, can be ranked as artillery, nor can we expect from its shots that which we do from projectiles charged with dynamite, as Lieutenant Zalinski has reported to his Government, and therefore it is useless to discuss it further here, what has been said sufficing to justify its exclusion." In connection with the Point-Lobos experiments, where the gun burst at the third round, he quotes Colonel Kelton as considering the results very satisfactory, since they had demonstrated the possibility of employing dynamite in shells. Much space is given to the experiments by the Snyder method, and this method seems to have made so favorable an impression upon Mr. Carrasco, that, in marking out a program of experiments for the purpose of verifying the results already obtained, and of proving the possibility or impossibility of the use of dynamite in projectiles, he seems to have decided to use the Snyder system in the firing trials.

It is interesting to read this *résumé* in connection with Commander Barker's account of his experiments in firing dynamite under service conditions, published in this number of our proceedings.

The Flood Rock explosion has naturally given rise to much literature on the subject, and among others we notice the paper by General John Newton, "The Improvement of East River and Hell Gate," *Popular Science Monthly*, **28**, 433–448, Feb., 1886; a note in the *Rivista di Artiglieria e Genio*, **1**, 160–170; 1886; an account of the blasting operations at Hell Gate, by L. F. Vernon-Harcourt, *Proc. Inst. Civil Eng.* **85**, 1–13; 1886; and another, "The Hell Gate Improvement," by Lieutenant George McC. Derby, U. S. A. (one of General Newton's assistants), in *Sanitary Engineer*, Dec. 3, 1885.

*Memorial de Artilleria, Nov., 1885.

†Van Nostrand's Eng. Mag. **32**, 3, Jan., 1885; Proc. Nav. Inst. **11**, 291; 1885.

This last is reprinted nearly in full in the *Illustrated Catalogue of the Rand Drill Company*, New York, 97–109; 1886. All of these are illustrated, the latter two especially so, as they show the methods of driving and charging and firing the mine, the nature and extent of the obstructions to be removed, and the appearance of the blast. The operations at Flood Rock are also noticed by M. G. Cerbelaud in his "Emploi de la Dynamite pour le Sautage des Grosses Mines," *Mem. Soc. Ingénieurs Civils*, 792–805, Dec., 1885.

We are indebted to General H. L. Abbot for six exquisite photographs of the Flood Rock explosion. Two of them were taken, one just before, the other just after the explosion, from a height of 260 feet above the water level. The other four were taken at the firing station, it being 1100 feet from the hoisting tower on Flood Rock. Of these, the first was taken just before the explosion, and the others at 0.2, 0.6 and 2.0 seconds respectively after the explosion. The first two views show that ignition by sympathy was transmitted so rapidly as to be practically instantaneous over the entire area of the rock, and that no failure occurred in any of the galleries. In a word, they demonstrate the entire success of this new mode of ignition. The height of the tallest jet was found to be about 160 feet. The charge of the mine is stated to have consisted of 240,399 pounds of rackarock and 48,537 pounds of dynamite No. 1.

We are indebted to General Abbot also for advanced sheets of his reports on the "Earth Wave at the Destruction of Flood Rock," and of his "Tests of Rackarock." In the first the data are given of the seismographic observations made at eight different stations, situated at distances of from about eight to one hundred and eighty-three miles from Flood Rock. From the discussion of these data the conclusions are reached that these observations indicate (1) an extraordinary velocity of wave-translation in both directions observed, which confirms General Abbot's deductions from the Hallet's Point and certain torpedo explosions,* that "the more violent the initial shock, the higher is the velocity of transmission." At Flood Rock the charge was about six times as large as at Hallet's Point, and the velocity was from two to three times as great over essentially the same route. (2). The uniformity of velocity to the northward, where the strata consist largely of homogeneous gneiss rock, and where the

* Am. Jour. Sci. 15 [3]. 178; 1878.

velocity even for 175 miles exceeded 20,000 feet per second. (3). The varying velocity which appeared to characterize the wave moving to the eastward, through the drift formation of Long Island. Here there seems to have been a gradual increase of velocity, followed by a decrease as the wave advanced; but on the whole a decidedly less rapid rate is indicated than in traversing solid rock, as might be expected in media of varying density and elasticity. This result, although not inconsistent with the Hallet's Point observations, was not discovered from them, except as to the decrease in velocity as the wave disappeared. This is the only point where the four deductions from the earlier observations are modified by this later and more accurately observed explosion.

The Flood Rock explosion appears to have caused a continuous earth-tremor, which, observed under a magnifying power of about 18, lasted about one minute throughout the whole region covered by the observations, the maximum disturbance leading the advance, or nearly so, for at least fifty miles. At extreme ranges the tremor appears to have broken up into successive waves with well-marked intervals between them. These facts, the instantaneous nature of the explosion shown by the photographs, and the varying rates of advance through strata not homogeneous, appear to warrant the conclusion that the oscillation followed different routes to any given point—some near the surface and others at greater depths, where more dense and elastic strata produced changes in the direction of the wave-front and yielded higher velocities.

The whole subject is evidently too complex to warrant definite conclusions as to the velocity of ordinary earthquake waves, where the intensity of the original disturbance must always remain unknown.

The tests of rackarock showed that a mixture containing 21 per cent. of nitrobenzol (sp. gr. 1.33) was the most efficient; that it was important to have the potassium chlorate used perfectly dry; that the resulting intensity does not differ, whether the explosive is loosely or solidly compacted in the can; that an explosion of the first order is certainly obtained when the charge is fired by two service fuses, each containing 24 grains of fulminating mercury in a copper cap; that the mean pressure obtained in the experiments was 108 per cent. of that of dynamite No. 1; that the contractor supplied for Flood Rock an explosive of much higher intensity than was exacted by the terms of his contract.

Gen. Abbot concludes: "This high intensity, joined to the advantages of entire safety in transportation, exemption from all danger in case of accidental exudation of the fluid from loaded holes, and other practical merits discovered in charging the mine, in my judgment more than confirm the wisdom of your (Gen. Newton's) selection of this new explosive in preference to any form of dynamite for use in a work of this exceptional magnitude."

We are in receipt of a pamphlet from the Rendrock Powder Co., New York, which describes the method of preparing rackarock for use, and of adjusting the primers, and contains a report of an examination of rackarock by George G. André, M. E., etc. etc. In addition to the other advantages claimed for this substance, he asserts that the gases from its explosion are of a much less harmful character than those from gun-cotton or dynamite.

The success which has attended the use of rackarock, panclastite and hellhofite, has led Dr. Hermann Sprengel to seek to establish his claims to priority of invention. The result has been a series of articles in the *Chemical News*, **52**, 215, 271 and 295; 1885, and these have been gathered together, with extracts from various sources, and published by Dr. Sprengel under the title "The Hell-Gate Explosion and so-called Rackarock." From this we learn that while Dr. Sprengel invented his safety explosives in 1870, patented them in England April 6 and October 5, 1871, and published an account of them in August, 1873, Mr. Divine filed a caveat for his invention in the U. S. Patent Office January 9, 1871, though he did not patent it until December 7, 1880. To Dr. Sprengel, then, belongs the priority due to publication, and also the credit of being the first to recognize and point out the general principles which govern the manufacture and mode of action of this very numerous and very important class of explosives.

From the equations ordinarily found in our textbooks, it would appear that when potassium chlorate is heated it is resolved into potassium chloride and oxygen; but Frank L. Teed finds, in his researches on "The Decomposition of Potassium Chlorate by Heat," *Chem. News*, **52**, 248; 1885, that the reaction is by no means so simple, but that we have also potassium perchlorate, formed thus:

$$10KClO_3 = 6KClO_4 + 4KCl + 3O_2;$$

so that for every 74.5 parts of potassium chloride produced there should be 24 parts of oxygen evolved; also, that when the potassium chlorate shall have yielded 7.84 per cent. of oxygen, all the chlorate is decomposed and nothing but perchlorate and chloride remains. Any further oxygen evolved results from the decomposition of the perchlorate. When manganese binoxide is heated with the chlorate, no perchlorate is formed. Dr. Armstrong thought these results indicated a higher molecular weight for the salt than the formula used requires.

In the *Chem. News*, **53**, 145–147; 1886, E. J. Maumené, under the same title, calls attention to the fact that the reactions of potassium chlorate occupied his attention so long ago as 1845–46, his results being published in *Ann. de Chim.* **18**, 41, and that later he obtained similar results to those quoted above; but he makes the reaction still more complex.

Dr. H. Carrington Bolton finds that potassium or sodium peroxide may be readily prepared by heating the nitrate to fusion in a test tube until oxygen is freely evolved and then dropping in pellets of the metallic radical. The metal burns with a bright light and forms the peroxide, which dissolves in the molten mass.

On attempting to examine in the same way the action of sodium upon melted potassium chlorate a violent explosion occurred, projecting fragments of the test tube and the melted salt into the face and over the person of the operator. The explosion was instantaneous, and accompanied by a loud report. On repeating this with suitable precautions, using a stouter tube surrounded by a metallic cylinder, similar explosions resulted, without, however, breaking the glass. Pellets of sodium no larger than a grain of barley cause sharp reports the moment they reach the surface of the melted chlorate. (*Chem. News*, **58**, 289; 1886.)

In connection with the recent rapid advances made in the liquefaction of gases, the following statement of Faraday's, drawn from the *Jour. Sci. Roy. Inst.* **16**, 229–240; 1823, entitled "Historical Statement Respecting the Liquefaction of Gases," may prove interesting:

The *Phil. Trans.* for 1797, p. 222, contains an account of experiments made by Count Rumford to determine the force of fired gunpowder. Dissatisfied both with the deductions drawn and the means used previously, that philosopher proceeded to fire gunpowder in

cylinders of a known diameter and capacity, and closed by a valve loaded with a weight that could be varied at pleasure. By making the vessel strong enough and the weight sufficiently heavy, he succeeded in confining the products within the space previously occupied by the powder. The Count's object induced him to vary the quantity of gunpowder in different experiments, and to estimate the force exerted only at the moment of ignition, when it was at its maximum. This force, which he found to be prodigious, he attributes to aqueous vapor intensely heated, and makes no reference to the force of the gaseous bodies evolved. Without considering the phenomena which it is the Count's object to investigate, it may be remarked that in many experiments made by him, some of the gases, and especially carbonic-acid gas, were probably reduced to the liquid state. The Count says:

"When the force of the generated elastic vapor was sufficient to raise the weight, the explosion was attended by a very sharp and surprisingly loud report; but when the weight was not raised, as also when it was only a little moved, but not sufficiently to permit the leather stopper to be driven quite out of the bore, and the elastic fluid to make its escape, the report was scarcely audible at the distance of a few paces, and did not at all resemble the report which commonly attends the explosion of gunpowder. It was more like the noise which attends the breaking of a small glass tube than anything else to which it could be compared. In many of the experiments in which the elastic vapor was confined, this feeble report attending the explosion of the powder was immediately followed by another noise totally different from it, which appeared to be occasioned by the falling back of the weight upon the end of the barrel after it had been a little raised, but not sufficiently to permit the leather stopper to be driven quite out of the bore. In some of these experiments a very small part only of the generated elastic fluid made its escape. In these cases the report was of a peculiar kind, and, though perfectly audible at some considerable distance, yet not at all resembling the report of a musket. It was rather a very strong, sudden hissing, than a clear, distinct and sharp report."

In another place it is said: "What was very remarkable in all these experiments in which the generated elastic vapor was completely confined, was the small degree of expansive force which this vapor appeared to possess after it had been suffered to remain a few minutes, or even only a few seconds, confined in the barrel; for upon

raising the weight by means of its lever and suffering this vapor to escape, instead of escaping with a loud report, it rushed out with a hissing noise hardly so loud or so sharp as the report of a common air-gun, and its effects against the leather stopper, by which it assisted in raising the weight, were so feeble as not to be sensible." This the Count attributes to the formation of a hard mass like a stone within the cylinder, occasioned by the condensation of what was, at the moment of ignition, an elastic fluid. Such a substance was always found in these cases, but when the explosion raised the weight and blew out the stopper, nothing of this kind remained.

The effects here described, both of elastic force and its cessation on cooling, may evidently be referred as much to carbonic acid, and perhaps other gases, as to water. The sudden strong hissing observed as occurring when only a little of the products escaped, may have been due to the passage of the gases into the air with comparatively but little water, the circumstances being such as were not sufficient to confine the former, though they might the latter; for it cannot be doubted but that in similar circumstances the elastic force of carbonic acid would far surpass that of water. Count Rumford says that the gunpowder made use of, when well shaken together, occupied rather less space than an equal weight of water. The quantity of residuum before referred to, left by a given weight of gunpowder, is not mentioned, so that the actual space occupied by the vapor of water, carbonic acid, etc., at the moment of ignition, cannot be inferred. There can, however, be little doubt that when perfectly confined they were in the state of the substances in M. Cagniard de la Tour's experiments.

When allowed to remain a few minutes, or even seconds, the expansive force at first observed diminished exceedingly, so as scarcely to surpass that of the air in a charged air-gun. Of course, all that was due to the vaporization of water and some of the other products would cease as soon as the mass of the metal had absorbed the heat, and they would concrete into the hard substance found in the cylinder; but it does not seem too much to suppose that so much carbonic acid was generated in the combustion as would, if confined on the cooling of the apparatus, have been equal to many atmospheres, but that, being condensable, a part became liquid, and thus assisted in reducing the force within to what it was found to be.

The Pharmaceutical Record, **6**, 349–350; 1886, publishes a "Tabulated List of Explosive Substances," by Charles D. Lippincott,

which embraces such articles as are likely to explode when triturated singly or when mixed with other substances, and also of such as are liable to undergo spontaneous combustion. The list is prepared for the drug trade, and contains some curious information.

A recent publication, which may be found of value in connection with the study of gun-cotton, is issued in the form of a thin pamphlet by C. F. Cross and E. J. Bevan, and entitled "Cellulose." These authors have given much attention to the experimental study of this little-known but commonly-occurring body, the results having been published in the *Jour. Chem. Soc.* and elsewhere, and summarized here. The pamphlet has been written to impress upon the younger chemists the importance of further research in this rich but much neglected field of investigation.

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EXTRACT FROM THE REPORT OF THE MARCH TO WITU BY THE LANDING PARTY OF THE GERMAN CORVETTE GNEISENAU.

Translated from Supplement to Marineverordnungsblatt by LIEUTENANT W. H. BEEHLER, U. S. N.

The Gneisenau arrived off Lamoo on the 28th of August, 1885, in obedience to the order of the Commander-in-Chief of the German East African Squadron, to obtain definite intelligence concerning the Witu district.

Commander von Prittnitz was sent in with three boats the next morning, in order to secure military command of the situation immediately. As soon as the boats crossed the bar, the Gneisenau proceeded to Manola and anchored close to the channel leading to Lamoo. Commander von Prittnitz was accompanied by Messrs. Denhardt and Küntzel as interpreters and guides for the march to Witu. At 4 P. M. Commander von Prittnitz returned on board with the report that the Bali of Lamoo was in command of the troops of the Said of Zanzibar at Kipini, on the Orzy River, with 1100 men, 450 of whom were regulars from the so-called guard stationed at Zanzibar.

This force had prepared an intrenched camp at 3000 metres from Witu, whence they intended to make their attack, when they received orders to return, without having committed any hostilities. An attack by the troops from Zanzibar had, however, not been feared in Witu, though they suffered considerably by the long, close blockade from the coast. Mr. Küntzel volunteered to remain in Lamoo to make preparations for the expedition.

The essential features of the march to Witu and return are related by Captain Valois as follows:

I left the ship at 5.30 A. M., August 31st, in the steam launch, with both cutters in tow, and proceeded up the channel to Lamoo, behind the island, around M'konumbi, from which point we commenced the

march to Witu. I detailed Lieutenant Gerstung to act as adjutant, Lieutenant Paschen as commander of the detachment, with Dr. Tereszkiewiez as assistant surgeon; two petty officers, twenty men, one musician, one hospital assistant, one commissary assistant, and the servants of the officers (being a total of thirty-three persons, officers and men). Eight days' rations were carried, and each man had sixty cartridges, while fifty rounds per man were carried as reserve in ammunition cases. The bearers brought by Mr. Küntzel from Zanzibar, and some pack animals from M'konumbi, were ready in the afternoon of August 30th.

As we passed Lamoo, at 7 o'clock in the morning, we met Mr. Denhardt, and continued our journey. At 11 A. M. we arrived at M'konumbi at low water, and immediately landed. I then decided to take up the march to Fungasombo immediately, in order to reach that place to bivouac for the night. The Seer of M'konumbi, who had been at Lamoo, came with Mr. Denhardt, and informed me that the Bali of Lamoo was aware of our intended march to Witu, and had issued orders that every assistance should be given us.

Mr. Küntzel had fifty-three bearers, two horses and three mules. The bearers were then detailed for the baggage, and at 1 P. M. we finally proceeded on our march to Fungasombo. The way led across a plain thickly covered with high grass, and the footpath was so narrow that the men were obliged to follow each other in single file. We arrived at Fungasombo at 4 P. M., having covered a distance of 8 sea-miles, measured by the piedometer. The pack was unladen and we encamped.

The march so far had not been difficult, as a light south wind freshened the air. Our arrival had been expected in the village, and a number of "kitandas" (sleeping-benches) and open straw mattresses were placed for us under some large mango trees. As the place was very small, we were obliged to bivouac. Only a few of the officers found shelter in a tent. Mosquitoes were so thick and pestiferous that it was impossible to get any sleep. The Seers and people of M'konumbi and Fungasombo were friendly and hospitable.

The march was resumed the next day, September 1st, at 6.30 A. M., after breakfast. The Pangani Lake was forded at 9 A. M. till 9.40 A. M. It was deemed unadvisable to make a *détour* of this lake, because too much time would have been lost. We rested in the shade of some bushes The men put on dry clothes and dined while the wet clothes were dried. The road to the lake led through grass

about six feet high, and obliged the men to march in single file. The ford through the lake was very narrow; the water reached half-way up the thigh, and the bottom was slimy and full of weeds, which made the forty minutes in the water very tiresome. This lake dries up entirely during the dry season, while in the wet season it is generally so deep that it can only be crossed by swimming.

At 1 P. M. we left the lake, and at 4 P. M. reached the Utesani forest, which we crossed in 20 minutes. We here met the first outposts of the Sultan of Witu, armed with guns, bows and arrows, who escorted us through the woods. We were expected at Witu, and when we passed through the forest we found ourselves in the Witu district, and arrived in the town at 6 P. M.

The distance covered from Fungasombo to Witu was about 4½ German miles. The path was over a gradually rising plain, but it was rough, and necessitated careful marching to prevent misstep. The greater portion was through tall, thick grass, which cut off every breath of air, and made the temperature, which was 86° F., much more oppressive. The mosquitoes infested the tall grass, and we were greatly annoyed, even in daytime. The country was apparently wooded, but in reality only had widely separated palm trees, which gave no shade whatever. The men overcame all these difficulties, with the exception of one man, who was obliged to have his comrades' assistance during the last stretch.

About 200 metres from the town we were met and welcomed by Sherif Abdallah, in the name of the Sultan. We were then conducted through the door of a palisade, and between the open ranks of the Sultan's warriors, to two houses which had been prepared for us. I then decided to have the interview with the Sultan the next morning.

The men had supper, and then retired to rest on the benches prepared for them in the dark rooms of the houses, where they were but little disturbed by the mosquitoes. There were but three slight cases of footsore men, but they did not impede the march.

The following details concerning Witu are from personal observations, together with information furnished by Messrs. Denhardt and Schlunke, Mr. Schlunke having lived in Witu for the past six months:

Witu has about 800 thatched-roof mud houses, generally without windows, and ventilated by the doors and the space between the walls and the projecting roof. All the houses are built of reed-work filled in with mud.

The house of Sultan Achmed is solidly built of smooth coral rock; it has a large carved door, but no windows, and it is kept scrupulously clean. A courtyard is enclosed by walls sufficient to contain a detachment of twenty-two men, in two companies, to serve as the guard against any attacks. On account of the blockade, which had lasted four months, they were deprived of many comforts, and for this reason the Sultan was not able to wait upon us with coffee and sherbet, as customary.

The site has an area of about 100 square yards, and is almost completely surrounded by a dense, impenetrable forest, and is only accessible through two palisaded gates with small doors, behind which a belt of the forest is cut away to make a street. Both gates are occupied by guards, on account of the proximity of the Arabs.

Near Witu there are two similarly fortified places, which serve to protect the exposed villages behind; at least they have never been captured by the Arabs, though during the last two and a half years new and more decided hostilities have been waged against Witu. At Witu there dwell from 2500 to 3000 men, though we found but 200 soldiers there, since the Sultan Achmed had sent the other 2000 men to their homes as soon as the Arabs withdrew.

The Sultan's soldiers are armed with flintlocks, percussion guns, bows and arrows, spears, and swords, some being detailed for guards at the gates and others for patrols. The men appear to be like the irregulars of Zanzibar, though somewhat more warlike, as might be supposed, from their arduous duty in holding such an advanced, exposed place as Witu. According to Messrs. Denhardt and Schlunke, the Sultan Achmed has 17,000 men under his command. This may appear to be an exaggeration, but the fact is that he has been able to hold this place against the most bitter enemies for twenty years.

In comparison with other East African places, Witu makes a favorable impression by its cleanliness and good regulations. The houses are not built compactly together, and many of them have small yards and gardens, with trees, etc. I did not see any dirty, lazy beggars, and I especially noticed the absence of all disagreeable odors.

The district is about 50 metres above the level of the sea, and the soil on both sides seems to be fruitful. A small tributary of the Osi would permit small, light-draught craft to approach to within one hour's walk in the dry season, and to within 1000 metres in the wet season. At this time we found sufficient water there for the men to bathe in, and in places up to their necks in depth.

The roads from Witu to the coast are mere footpaths, though there would be no difficulty in widening them. The ground is generally level and hard, except the marsh of Pangani, and several other places of very little extent. The paths are in this condition because it is customary for the caravans to proceed in single file instead of in pairs.

Between M'konumbi and Witu we did not meet the smallest tract of barren, sandy soil; every spot of ground was covered with grass and agricultural products. We found Indian corn, beans, olives and tobacco. The last is cultivated by the inhabitants for their own use, or for barter.

The land is rich in cattle. At M'konumbi there were 300 head of cattle, and I was astonished to learn that it is more difficult to raise cattle in the wet season than in the dry, because in the wet season the prevailing dampness causes a great deal of sickness. The crude manner in which young cattle are branded to mark their ownership must be a great cause of loss. I saw young calves scarcely able to stand with bloody foreheads made by cutting deep crossmarks, and others with deep rings cut out around their eyes.

Beyond Fungasombo all agriculture ceased up to beyond the Utesani forest; this was owing, doubtless, to the war.

At 9.30 A. M., September 2d, I went to call on the Sultan, accompanied by the officers, the German gentlemen and the detachment, and on the way passed through the drawn-up lines of his soldiers. After the Sultan had reviewed the sailors, and had shaken some of them by the hand, the detachment withdrew. It gave the Sultan a great deal of pleasure, subsequently, when I gave him a chromolithograph of the Emperor (full view, with Paris in the background). The interview was carried on by the adjutant, Lieutenant Gerstung, Lieutenant Paschen, Assistant Surgeon Tereszkiewiez, Messrs. Denhardt and Schlunke (the latter acting as interpreter), and by the Sultan's heir, Fumo Bakari, and several nobles of his kingdom.

In the afternoon the heir, Fumo Bakari, returned my call, and at the same time requested permission to send to Kipini to purchase supplies. In consequence of the blockade, cloth, oil, soap, petroleum, etc., were greatly in demand. By this mission it would be able to ascertain definitely if the Arabs intended to keep up hostilities, and I promised that in case any of his people should be held captive, I would intercede for their freedom in Lamoo, and also at Zanzibar.

The persons detailed to go to Kipini left early in the morning of

September 3d, and returned that evening, to the great joy of the entire community.

In the afternoon of September 3d I went with the officers and the German gentlemen to bid farewell to the Sultan, and at the same time presented him with some clothes and a roll of blue cloth, after I had presented the heir with my Mauser magazine-rifle.

We were quartered in two houses, and were quite comfortable. The men slept on "kitandas," low wooden benches, and were well provided for. The Sultan gave us one young ox, three sheep and a number of fowl, so that our supply of fresh meat was rich. The meat was tender and palatable.

That night the natives danced a war-dance by torchlight, in our honor, and at 6.30 A. M. on September 4th I began the march back.

In accordance with the wish of the Sultan, we marched by his house, where I took leave of him, after which I was conducted by Fumo Bakari and the Sherif of Witu as far as the gate. We crossed Lake Pangani at 11 A. M., when we halted for rest and cooked dinner. The march was resumed at 2 P. M., and at 4.30 P. M. we entered Fungasombo.

The return march from Witu to the sea was made in less time than before, because the men were fresher, and had started early in the morning. The men held out well, and entered Fungasombo singing. The man who had previously shown signs of weakness became helpless in crossing the lake, and was obliged to finish the journey on my horse. His helplessness was constitutional, and shortly after our return on board ship he recovered entirely. We encamped at Fungasombo that night, as before, but the swarms of mosquitoes made it impossible to get any sleep.

We left Fungasombo at 7 A. M., September 5th, and arrived at M'konumbi at 9 A. M., having had cloudy weather with light rain. It was very pleasant and agreeable. There were about 3000 head of cattle in the vicinity of M'konumbi, so that the men fared well on sweet and sour milk in abundance.

The boats from the ship came in at 2 P. M., and by 2.30 the detachment and baggage embarked in the boats and we proceeded with the ebb-tide. At 6 P. M. we anchored off Lamoo, because the tide was so low that we could not pass through the channel to Manda Bay. The men ate and slept for the night in the boats.

In the morning of the 6th of September I had an interview with Seleman Ben Hamed, who had been sent by his brother, the Bali of

Lamoo, from Kipini to pay his respects to me. He requested me to take a messenger with letters to Zanzibar, which I promised. I then bade farewell to Seleman and sent greetings by him to his brother, besides writing him a note, which I gave to Mr. Schlunke to interpret. We then returned to the ship, where we arrived a little after noon.

Further details as to the experience of the march are given in the reports of the Chief of the Detachment, Lieutenant Paschen, and Assistant Surgeon Tereszkiewiez.

I.—Equipment.

Though the expedition was of a friendly character, yet the officers and men were thoroughly equipped as if for a hostile object, upon the basis of an eight days' absence from the ship, as follows:

1. *Clothing.*—Straw hat, with havelock, undershirt, drawers, working blouse, working trousers, cape, woolen socks, boots, handkerchiefs, knife and sheath.

2. *Armament and Equipment Carried by Each Man.*—Two petty officers and twenty men were equipped with: Rifles, cutlasses, leather belts with two cartridge-boxes, each with twenty cartridges; haversacks with twenty cartridges, one day's ration of hard bread and sugar, gun-cleaning utensils, handkerchief, smoking utensils, and canteen of water with a little rum. Seven men also carried battle-axes, other seven had spades, and four carried camp kettles; these articles were carried by canvas slings over the left shoulder. Eight men (four servants, one hospital assistant, one musician, one porter, one steward) were equipped as follows: Cutlasses and belts without cartridge boxes, revolvers with eighteen cartridges, haversacks, canteens. The hospital assistant also carried bandages, while the musician carried his bugle.

3. *Equipments Carried in the Pack.*—(*a*) Undershirt, pair of drawers, working blouse, working trousers, pair of socks, pair of leather shoes, cap and cover, cape, comb and soap, towel, handkerchief, sewing-needles, white and black thread, some buttons, woolen blanket, waterproof cover. These articles were rolled in the blankets and waterproof cover and secured by three turns in the middle and at the ends. A wooden tablet with the name of the owner was fastened to the lashing.

Besides the above for each man, the pack also contained the following articles: (*b*) Three cases of reserve ammunition, each with

three hundred and eighty rifle cartridges and thirty revolver cartridges; large boiling-pot, smaller boiling-pot, three teakettles, thirty knives, forks and spoons, can of oil, gun-cleaning material, three lanterns, thirty candles, four large filterers, coil of lashings, eight reserve wooden tablets, about fifteen fathoms of old canvas to bind up broken packages, eight boxes of kindling-wood.

(*c*) *Provisions.*—Corned beef for three days, salmon for two days, preserved meat for three days—eight days; rice for four days, peas for two days, beans for two days—eight days; sugar for eight days; coffee for eight days; tea for eight days; hard bread for seven days, fresh bread for one day—eight days; butter for eight days; twelve litres of rum, one litre of vinegar; salt, pepper and onions.

The articles mentioned in (*a*), (*b*) and (*c*) were put in packages of about twenty-five to thirty kilogs. (55 to 66 pounds in weight). Four packages of blankets, etc., were tied together to make one bundle. Three mess chests were used to pack the articles mentioned under (*b*), and the provisions under (*c*) were carried in small chests; making a total of thirty-four packs; to which should be reckoned the seventeen bundles of equipments belonging to the officers.

II.—The Order of March.

The order of march was so regulated that one-half of the detachment was led by a petty officer; the bearers then followed; while the other half of the detachment, with the commanding officer and the surgeon, brought up the rear. In other respects the order of march was controlled by the road, which was so narrow that two men could not march side by side. The column was thereby considerably extended, so that it was difficult for the commander of the detachment to control the men and direct the march.

The stretch as far as the Fungasombo was made with cooler weather (with a fresh southerly wind), and covered in two and a half hours. The men also had occasional halts, whenever the bearers had to rest.

In the little village the site of the camp was selected for the night on dry ground covered with short grass, under the trees. Want of sufficient space prevented quartering in the huts. The first attempt at cooking failed entirely. The rice was burnt, and had to be thrown away. As the time for the midday meal had long been passed, coffee with corned beef and bread and butter was served out instead of a warm dinner. In the evening and during the night the camp was

infested by mosquitoes, and so much so that it was impossible to get any sleep. All attempts, such as covering one's self in the blanket, putting socks on hands and feet, pulling the caps down over the head by loosening the strings, etc., were in vain and gave no protection, even though a fire was kept burning all night near the camp to keep the mosquitoes away. At the inspection at midnight and 2.30 A. M. not a single man was found asleep. Some had gone to the fire, some had climbed up into the trees, as mosquitoes are said to confine themselves to a very limited height above the surface, and the others walked about the camp smoking. The next morning every one was covered with mosquito-bites, not only on the exposed portions, but also where the person was covered by underclothing and working dress. Two of the officers took refuge in a hut, and claimed to have found some protection under a mosquito net.

At daybreak the next morning the woolen blankets were rolled up and the men washed their faces and hands, but did not bathe, because there was a lack of water, and also because it was not advisable to expose the person to mosquito-bites. After breakfast the pack was rearranged, arms cleaned, and canteens filled with fresh filtered water with a little rum. At 6.30 A. M. the march to Witu was resumed. Shoes were worn for this portion of the march, as it was necessary to cross a swamp three feet deep, and it was deemed easier to do this in shoes rather than with the boots. The path led through grass four feet high, which farther along was eight feet high. At 9.30 A. M. we reached the swamp, which was crossed in forty minutes, and during this period the men were in the water up to their hips. The contents of the haversacks were wet. The passage of the swamp was rendered especially difficult by the marsh-grass, which necessitated raising the feet at every step to near the surface to disentangle them. The temperature was also higher on this day, and we missed the fresh seabreeze which made the march to Fungasombo so pleasant. One man fainted while in the water. He was given some port wine and water, relieved of his weapons and equipments, and was soon able to resume the march.

On the opposite shore of the swamp the troops halted at 10.30 A. M., under the shade of some trees. A half ration of brandy was then served out, the men changed their clothes, and, while their wet clothes were hung up to dry, sought some rest, which here, as elsewhere during the entire march, was impossible on account of the mosquitoes. The march to Witu had to be resumed at 1.30 P. M. in order to be

able to reach that place before dark, and therefore there was not time to cook vegetables, and the midday meal was the same as that for the day before—coffee, corned beef, bread and butter.

During the four and a half hours' march to Witu we halted twice for about five or ten minutes. A part of the way led through a thick forest, which gave some protection from the sun. We arrived at Witu at 6 P. M. By direction of the Sultan, two large mud houses, one for the officers and one for the men, were placed at our disposal. These houses were found to be, like the entire village, remarkably clean and had been evidently unoccupied for a long period, for which reason we did not hesitate to use them. The men were comfortable, especially as the Sultan had provided resting-benches made of plaited straw, called "kitandas." There was ample space for all the men in the three sleeping-rooms, and the fourth served for stowing the arms and pack. One of the sleeping-rooms was used as a kitchen, and this use operated in driving away the mosquitoes and resulted in giving the men good rest at night.

We remained here three nights and two days, during which time the men had fresh provisions. One day dinner consisted of pork and beans, the next pork and rice, and on both days they were palatable. With a little money the men were able to buy fresh milk and eggs for breakfast and supper, so that nothing better could be wished for. There were no drills during our stay. The care of the clothes, washing, drying, and greasing boots and shoes, cleaning weapons and keeping the quarters clean and in order, occupied all their time sufficiently. Once the men were called out to review by the Sultan, and another time there was some target practice for the heir to the throne. In the evening the men had opportunity to bathe in a pond near the village, but in undressing and dressing they were so much exposed to mosquitoes that it was a questionable pleasure.

At 6.30 A. M., September 4th, we began our return march. The provisions for the first day consisted of fresh meat, cooked before our departure from Witu, and on the second day the chief meal consisted of corned beef and coffee. We arrived at M'konumbi at 11 A. M., September 5th, and at 2 P. M. the same day embarked in the boats.

III.—The Efficiency of the Equipment.

The equipment of the detachment proved to be thoroughly satisfactory, and it was found to be practicable to pack the individual articles belonging to the men in their woolen blankets. It is necessary, how-

ever, for the waterproof cover to be of strong material, by which the woolen blanket and its contents are preserved from injury in transportation. It would be advisable to have leather straps and buckles, to facilitate securing and opening the packages.

The straw hat proved to be a comfortable and convenient covering for the head, as it was light and rested securely without pressure on the head. The havelocks were made of too thin material to give the necessary endurance for a longer expedition.

The allowance of provisions was not satisfactory. Vegetables should not be taken on such an expedition. It requires too much time to prepare them. Such an expedition should take meat extracts, sausages, and preserved potatoes.

The camp kettles should always be taken on similar expeditions, for otherwise there would be nothing in which to get water for cooking or to filter with; and it is not always practicable to camp in the immediate vicinity of water. These camp kettles are also convenient for carrying smaller articles, such as hard bread and tins of sausages and canned meats. They may be put in linen bags and stowed in the kettles, and during the halt may be taken out, and then put back after the march is to be resumed. Our men did this, and the articles in the kettles did not get wet on crossing the lake, and would have been dry in the heaviest rain. These camp kettles increase the weight to be carried, but they render it feasible to dispense with mess-gear and cooking-utensils, while they can contain a spoon and fork without liability to injury, which is otherwise not so likely. The camp kettles, carried by the men on the march to Witu in canvas straps, caused no complaints, and they are deemed to form an efficient part of the equipment. In case an expedition intends to halt for an entire day, it would be advisable to have larger cooking-kettles, wherein a meal for twenty-five men could be cooked at a time. If the large cooking-kettles are to be taken, the large spoons and forks must not be forgotten. It would also be advisable to take a pair of iron tripods sufficiently high to enable a fire to be kindled under them. These would have to go in the pack with the articles enumerated under (*b*).

IV.—Medical Outfit.

This consisted of the regulation allowance of tourniquets and bandages in a bag carried by a bearer, besides which the hospital assistant carried bandages, and the following in packages ready for immediate

use: Spiritus aetherus, liquor ammonii caustici, twelve quinine powders of 5 g. each, tincture opii, and eight boxes of salicylic tallow.

The following sanitary precautions were observed: The men were strictly cautioned not to drink any water which was not filtered in the large filterer carried with the expedition. But as the process of filtering the water occupied a long time, it was difficult to control the use of the small filterers which the men carried.

When sleeping at night without cover, a fire was kindled near the camp to drive away the mosquitoes by the smoke, but there was no appreciable benefit by doing so. It would be advisable on a similar march to have the men sleep in huts, or at least to select the site of the camp remote from trees, which are favorite resorts of mosquitoes.

In the morning of the second day's march the men rubbed their feet with the tallow. This precaution was well taken, as only three of the men became footsore. The men stood the journey to and fro very well. Only one man was overcome, and he was obliged to make two long stretches on horseback. Upon our return on board ship, all were well excepting slight swellings on the feet. Two of those who were footsore soon recovered, and the other one had to wear protecting bandages. The hospital assistant, Schliwa, had an abscess on the arm as a result of a mosquito-bite, and it was necessary to send him to the hospital for treatment.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

FORCED COMBUSTION.

By Cadet-Engineer J. E. Byrne, U. S. N.

While the gradual introduction of the triple-expansion engine is producing such marked increase in marine economy as 14.2 pounds of water per horse-power per hour, as shown by the diagrams of the trials of the Mascotte, and 13 pounds of water per horse-power per hour, as claimed for the Dynamo, ships carrying about 160 pounds pressure, an increase of fully 25 per cent. in the economy of ships of same power using steam of 95 pounds pressure, the question of high combustion is becoming daily a rival of equal importance in the minds of marine engineers. Where heretofore economy alone was the sole end, with a fair rate of speed, shipowners, especially of the Transatlantic lines, are becoming impressed with the belief that speed pays, and the immediate future will see ships of higher speeds rather than those of lower. In the naval marine of the world the importance of high speed has long ago become an established fact, and engineers recognize the fact that future improvements in the naval marine engine will be made greatly in this direction. Extremely high speeds necessitate light weights and high rates of combustion, regardless of economy, although the variance of the economy attained at fair speeds from that attained from extremely high speeds is not so great as it was formerly supposed it would be. While, however, the triple-expansion engine has advanced to a state of excellence, the general adoption and perfection of high rates of combustion have made but slow strides, owing to the insufficiency of the data relating to this important topic, especially with relation to the life of boilers, obtainable by the marine designer. Notwithstanding the evident advantages accruing from the present use of forced draught in vessels of war,

many difficulties will have to be overcome in the systems now in use before a state of perfection will be reached. The air-tight fire-room, with its many objectionable features, is at present probably the most used of known methods of increasing the supply of air.

During the months of August and September of the present year a series of experiments was performed at the Washington Navy Yard, under the supervision of the Bureau of Steam Engineering, for the purpose of determining with some degree of accuracy the rates of combustion, the evaporation, and the variations of air pressure at different parts of the boiler, under air pressures varying from .4 of an inch to 4 inches of water, in a particular type of boiler. The type of boiler used is that known as the "low" or "marine locomotive" type. It was originally designed with the furnace front filled with fire-brick. The blast was introduced into the ash pit, and the air, besides passing through the grate bars, passed up through holes in the dead plate, and thence through perforations in the lining of the furnace door, over the fire. Air was also allowed to enter through suitable holes into the bottom of the intermediate connection. With this arrangement the tops of the grate bars and bridge wall burnt off very rapidly, and the intermediate connection filled with coal dust and ashes to such an extent that the four lower rows of tubes were covered before the end of a four hours' experiment. Alterations being necessary, the brickwork was removed from between the furnace front and lining, the entire lining was perforated with holes to correspond with the furnace-door lining, and the front corner of the intermediate connection was filled with fire-brick, apertures being made for the admission of air into the intermediate connection. This arrangement worked so satisfactorily that the grate bars and bridge wall remained uninjured throughout the remainder of the experiments. Tabulated results of the experiments are given in Table No. I, and the principal dimensions of the boiler used are as follows:

Diameter of boiler, 7 feet; length of boiler, 15.25 feet; total grate surface, 21 square feet; total heating surface, 687.3 square feet; calorimeter, 5.3 square feet; steam space, 165 cubic feet; water space, 245 cubic feet; ratio of g. to h., 1 : 32.73; ratio of c. to g., 1 : 3.96. Tubes were of brass.

Jerrold's patent method of setting the fire ends of tubes, which consists of drilling the front tube sheet in such a manner that it can be beaded over on to the ends of the tubes, thus making a flush job and yet securing the tubes safely, was used for the purpose of determining its effi-

cacy in enabling them to withstand the intense heat of high rates of combustion. At the end of the experiments the tubes were found to be uninjured. The coal used was Cumberland Valley bituminous.

TABLE I.

NATURAL DRAUGHT.

Hours.	Coal per Hour.	Steam.	Ashes in Furnace and Ash-Pit in Lbs.	Ashes in Back and Intermediate Connections in Lbs.	Temp. Feed Water.	Pressure in Ash-Pit in Inches.	Pressure in Back Connection in Inches.	Pressure in Furnace Doors in Inches.	Water Evaporated per Lb. of Coal from and at 212° F.	Coal per Square Ft of Grate per Hour.
4	210	80	.....	.....	80	.....	.....	.....	9.11	10
4	262.5	80	.....	.....	80	.....	.....	.....	9.11	12½
4	315	80	.....	.....	80	.....	.....	.....	9.93	15
4	367.5	80	.....	.....	83	.....	.....	.....	9.50	17½
4	420	80	.....	.....	81	.....	.....	.....	? 10.2	20
4	472.5	80	.....	.....	82	.....	.....	.....	7.29	22½
4	525	80	.....	.....	80	.....	.....	.....	? 8.19	25

FORCED DRAUGHT.

4	577.5	80	200	208	78	.6	.....	.6	8.24	27.5
4	630	80	180	264	78	1.1	.....	.6	7.49	30
4	682.5	80	271	194	78	1.	.....	.6	7.79	32.5
4	735	80	365	279	78	1.3	— .1	1.1	7.23	35
4	787.5	80	358	373	82	1.5	— .2	1.	7.24	37.5
4	840	80	350	425	79	1.7	— .2	1.2	6.61	40
4	892.5	80	390	475	80	2.6	— .4	2.	6.12	42.5
4	945	80	413	661	79	2.6	— .2	1.6	6.25	45
4	1050	80	560	1130	76	4	— .4	2.6	5.51	50
4	1050	80	552	1238	76	3	— .3	1.9	5.51	50

At this point the experiments were discontinued on account of the change of the function of the yard.

These results are apparently low, and do not equal those claimed to have been obtained in an article, by Messrs. Marshall and Weighton, read before the Institution of Naval Architects during the present year, and given in Table No. II., nor those obtained by the Admiralty with the ordinary locomotive type of boiler as used in the torpedo boats of Messrs. Thornycroft & Co., and given in Table No. III. Much of this disparity, however, can evidently be traced to the difference in the qualities of the coal used.

Table II.

Duration of Trial in Hours.	Ratio of Heating to Grate Surface.	Steam Pressure.	Coal per Square Ft. of Grate per Hour.	Evaporation per Lb. of Coal from and at 212° F.	Air Pressure in Stokehold.	Quality of Coal Used.
1.32	42.5	125.5	98.3	6.969	3.54	Cowpens coal, company's best.
1.23	42.5	125	107.9	6.889	3.605	do.
1.13	42.5	123	120.8	6.62	4.955	do.
1.5	42.5	120	118.1	6.566	3.07	do.
1.41	42.5	116.2	88.5	8.566	2.0	Nixon's Navigation, new and dry.

Table III.

Duration of Trial in Hours.	Ratio of Heating to Grate Surface.	Ratio of Grate Surface to Calorimeter.	Steam Pressure.	Coal per Square Ft. of Grate per Hour.	Evaporation per Lb. of Coal from and at 212° F.	Air Pressure in Stokehold.	Quality of Coal Used.
2	32.7	700	117	48.94	8.49	2	Nixon's Navigation.
2.1	32.7	700	117	62.2	7.90	3	do.
1.64	32.7	700	115	78.9	7.60	4	do.
1.48	32.7	700	115	96.03	7.15	6	do.

PROFESSIONAL NOTES.

[From *Tablettes des deux Charentes*, Sept., 1886.]

A series of experiments has just been made against the Bullivant nets surrounding the armored corvette Belliqueuse. The Minister wished to show that these nets cannot be efficacious except at a great distance from the hull, thus necessitating long spars difficult to handle, inconvenient to stow clear of the anchors, boats and guns; and, in short, he wished to show that the defenders of the Bullivant net are dreamers. In this case, as in the Protectrice experiments, the Minister took every precaution to cause the result to favor his own view; nevertheless he failed.

The charge was 55 kilograms of dry gun-cotton—three times the present charge of torpedoes—and the old wooden hull of the Belliqueuse was completely rotten. Nevertheless, in spite of these severe conditions, the results were as follows: At 9 m., no damage; 8 m., no damage; 7 m., oakum came out for two metres along a seam; 6 m., no damage; 5 m., no damage.

The effects having been nothing at 5 m. and 6 m., it was concluded that the oakum of a seam coming out at 7 m. indicated nothing, and was due to the defective caulking of such an old hull. Certainly an iron hull would have suffered no damage, and all experiments should regard only this class (iron) of armored vessels.

[From the *London Times*, Sept. 18, 1886.]

TORPEDO EXPERIMENTS AT PORTSMOUTH UPON THE RESISTANCE.

* * * * The former experiment had shown that the progress of a locomotive torpedo could be effectually arrested by the ordinary service protective nets now in use, and that the burst of a full-service charge of gun-cotton at the theoretical distance of 30 feet was perfectly innocuous. Yesterday morning the attack was advanced to closer quarters, and as the value of the nets had been demonstrated, it was deemed no longer necessary to employ costly Whiteheads in the assault. A fixed charge of gun-cotton, representing the normal explosive energy of a Whitehead, was accordingly slung from the booms at a distance of 20 feet from the skin plating (10 feet nearer than before) and submerged to the depth at which a torpedo would be set, and afterward electrically exploded from a cutter. The explosion produced the usual detonation and spout of water, but its force expended itself in the air, without inflicting any perceptible damage to the old hulk, which still continued to hold its own. A second charge of the same character and weight was afterward sunk 5 feet nearer the ship—that is, 15 feet from the side—and exploded in a similar way. In this case the differences were manifest and significant. * * * The Resistance was greatly strained and shaken, and though the booms remained in place, and none of the bottom skin was displaced, it began to leak, until eventually the wing passage in wake

of the target compartment became filled with water, and several runlets found their way into the bilges. Without docking the hulk it was found impossible to say what actual damage had been done.

The Resistance is an iron-armored broadside vessel of about 6000 tons, built about 1860.

TRIALS OF SMALL-ARM POWDER,

Showing the Progress Made by the Firm of Rottweil in the Past Three Years.

[From *Rivista di Artiglieria e Genio*, June, 1886.]

		Initial Velocity. German Service Powder. M.	Rottweil Powder. M.
11 mm. gun charge, 5 g.	Lead bullet, weight 25 g.	437	501
	Lead bullet covered with copper, wt. 25 g.	434	489
	Hardened lead bullet, weight 24 g.	449	512
	Internal pressure about equal for the three projectiles (atmospheres).	1484	2275

The useful gain was thus 60 m. of velocity, with undesired increase of 800 atmospheres.

Later trials give:

			Initial Velocity. M.	Internal Pressure. Atmospheres.
9 mm. gun with hardened lead bullet of 15.5 g.	German service powder, 4.3 g.		505	1625
	Compressed Rottweil powder, No. 5	5.2 g.	558	1655
	" " " No. 7		583	1530*
	" " " No. 15		600†	1655

W. L. R.

ORDNANCE NOTES.

Serving and Operating Guns on Board Ship.

The weight of the new service ammunition (of calibres above 6 inches) is so great as compared with that of the old, that the existing methods of handling it are likely to produce serious delays in loading. It is the intention of the Bureau of Ordnance to substitute, where necessary, mechanical power for manual labor in this connection, and a study is now in progress of the best means to the desired end. It is not impossible that ships of similar type may be equipped in different ways, in order to establish practically the relative value of steam, compressed air, water and electricity as vehicles for conveying and utilizing the energy required. Each of these prime motors presents certain disadvantages. Thus, in the event of rupture of the conduits, much inconvenience would arise if they carried either steam or water, both on account of the escaping matter and the difficulty of effecting rapid temporary repairs.

* Less smoke and less residuum in the barrels.

† The ordinate at 150 m. of the 300 m. trajectory is 46.4 cm.

Compressed air is subject to the last-mentioned drawback. On the whole, electricity bids fair to become a formidable rival to steam, air and water through the ease of laying and mending the conductors. Already certain electric motors command serious attention through compactness of design and efficiency in operation. These, as well as steam, air, and water engines, will be used not only to run in and out, train and point the guns, but, in addition, to hoist and haul shot and powder and to sponge and load guns. The results of this competitive trial will be of great interest to the naval profession, and will possibly solve other problems of ship economy, such as winches, capstans, boat hoists, etc.

Electric Firing of Guns.

Electricity has already been used in our Navy for simultaneous and other firing, the source of electricity being apart from the guns. For individual firing, the voltaic cell and secondary battery have been carried by the gun captain. It is proposed to lessen the inconvenience to him by placing the cell or battery on the slide or top carriage, as may prove most desirable.

C. F. G.

The 8-inch B. L. R. No. 1 (Mark 1), of steel, constructed at the Washington Navy Yard for the U. S. S. Atlanta, has been fired twelve (12) times at the Naval Ordnance Proving Ground with results as shown in the following table:

Charge.	Projectile.	I. V.	Pressure.
85 lbs.	250 lbs.	1706 fs.	11.6 tons.
100	250	1804	12.3
110	250	1966	15.9
110	250	1914	15.7
110	250	1858	12.8
110	250	1845	12.5
120	250	1990	14.4
120	250	1985	14.5
120	250	1977	14.8
122	250	1999	15.2
122	250	1980	15.2
123	250	2013	15.5

The gun was fired for the purpose of testing the gun and carriage, and to develop powder for guns of its calibre. The carriage used was the gravity-return barbette carriage shown in Plate 11, Report of Secretary of Navy, 1885. The gun has developed no defects of any kind, the breech mechanism and gas check (De Bange) working well. The carriage proved itself strong and capable of handling the gun with ease during elevation, training, recoil and counter-recoil.

C. E. B.

The Statutory Tests of the 6-inch and 8-inch B. L. R.'s.

On November 4, 1886, the rapid-firing test ordered by Congress was made before the Board detailed by the Secretary of the Navy, composed of Captain John A. Howell, Lieutenant John F. Meigs and Lieutenant A. M. Knight, U. S. Navy. The Superintendent of the Naval Academy and a large number of officers were present to witness the tests. The firing was under the immediate charge of Lieutenant Knight, with gun-crews composed of the regular employes of the Ordnance Proving Ground, some of whom were colored laborers. After every round the guns were quickly sponged with a very wet sponge. The heating of the guns was not great, and the hand could be held against them

after the firing of the ten rounds. The projectiles were fired into an embankment within 100 yards distant. The following data present a showing that will be of great interest to the service—viz.:

8-inch B. L. R. (on barbette carriage): Projectile, 250 pounds; charge, 121 pounds Westphalian powder; initial velocity, 1991 f. s.; pressure, 14.6 tons per square inch; time of firing ten rounds, 15 minutes and 7 seconds; number of men in crew, 8.

6-inch B. L. R. (on broadside carriage): Projectile, 100 pounds; charge, 50 pounds Dupont's brown prismatic powder; initial velocity, 2025 f. s.; pressure, 14.9 tons per square inch; time of firing ten rounds, 11 minutes and 43 seconds; number of men in crew, 8.

J. W. D.

FRANCE.

[From *Le Courier des États Unis.*]

The Hoche was launched at L'Orient October 1, 1886. This vessel is 334.5 feet long, 65 feet 7 inches breadth of beam, draws 28 feet 3 inches and displaces 10,581 tons, has a double bottom for a portion of her length, and is divided into numerous water-tight compartments by bulkheads both fore and aft and athwartships; is protected, 1st, by an armored deck 3.6 inches thick, which extends from one end to the other, and protects all the vital parts—*i. e.*, engines, boilers, steering gear, etc., etc.; 2dly, by an armored shield the plates of which are 17.7 inches at the upper end and 13.77 inches at the lower. The coal bunkers also protect the engines and boilers. Finally, a part of the bow has been filled with cellulose matter, which has given excellent results in stopping leaks.

Armament.—Two 14.56-inch guns in closed turrets, situated on the fore and aft line of the ship, one forward and the other aft. (These guns weigh 75 tons, throw a conical projectile weighing 1232 pounds, capable of piercing a plate of wrought iron 24.4 inches thick at a distance of 3280 feet.) Two 13.38-inch guns in barbette turrets, one to starboard, the other to port (these guns weigh 52 tons), throw a conical projectile of 924 pounds, and can pierce 22.84 inches of wrought iron. Finally, eighteen 5.5-inch guns; revolving and rapid-firing guns, the number of which has not yet been determined, and 6 tubes for launching auto-mobile torpedoes. The turrets will be covered with 13.75-inch armor. The Hoche has two military masts with tops, in which are revolving cannon.

The motive power consists of two independent engines, placed beneath the armored deck and separated by a strong midship bulkhead; each engine works a screw. Full horse-power 12,000. The speed should be 16½ knots. The Marceau, a sister ship, was launched at Toulon in 1884, and will be finished next year (1887). Two others of the same class are building—the Neptune, at Brest; the Magenta, at Toulon.

A new class of coast-guard armored ships is building in France. The six first-class are named Tonnant, Furieux, Tonnerre, Fulminant, Vengeur and Tempête. These formidable engines of war measure as follows: Length, 248 feet on water-line; beam, 57 feet 9 inches; depth, 18 feet; draught of water, 16 feet 9 inches; displacement, 4523 tons. The armor is 9.8 inches forward, 13 inches amidships, and 9.5 inches aft. The battery consists of two 13.4-inch turrets, one forward, the other aft, and four revolving guns on deck. The turrets are protected by plates 13.75 inches thick. 197 men compose the crew. Six of the second class of coast-defense vessels have also been ordered, which will have less armor and smaller guns.

A rifle 8 millimetres (.315 inch) has been invented and perfected by some infantry officers at Chalons. There are two models of this rifle, one single-fire, the other repeating. The first is preferred by competent judges, but it is difficult to persuade the masses that a single-fire rifle is preferable to a repeating rifle; hence, it is probable that the latter will be adopted. This small-calibre rifle has ballistic qualities superior to any yet tried. The projectile is very long, with a very fine covering of brass or steel, which strengthens it completely, and preserves its shape. The ball has an initial velocity of more than 1640 feet per second. The powder has been specially prepared for this rifle, and belongs to the category of progressive powders; that is to say, it is one which makes the recoil not a shock, but a push. It makes but little report, and so little smoke that, at a short distance even, one might not have his attention attracted. The trajectory is so straight that, at a distance of 1900 feet, it only rises 6 feet 6 inches. The Ministry of War hopes to obtain the necessary funds to complete the change of rifles.

Germany has decided to arm all troops with repeating rifles. It is said that the Government manufactories and arsenals have been ordered to transform the Mauser rifle, now in use in the army, into a repeating rifle of ten shots.

A shell is mentioned as being experimented with in England. It is made of steel, can perforate an iron target 18 inches thick, and can sink the largest ironclad afloat. This shell is a French invention.

The English are also going to try the new Schulhoff rifle, which fires 24 rounds a minute. On pressing a spring one can change it into a double-arm firing 52 shots a minute. This weapon will probably be adopted by the Austrian Army.

Experiments have taken place in the Department of Aisne, France, with shells filled with a substance of which the French Government holds the secret of its manufacture. Its power is double that of mélinite. There is no more danger in handling it than there is with ordinary powder. Its use will diminish the calibre and weight of guns. D. H. M.

THE STEAMSHIP AMERICA.

[From *Transactions of the American Society of Civil Engineers*, April–July, 1886.]

From the paper on the steamship America, by Robert Gordon, the following is taken as of general interest: In the shape of her hull, the America is the embodiment of principles discovered by the late Mr. W. Froude, who, while experimenting on models of ships, found, contrary to the expectation and practice of naval architects, that a comparatively short and broad ship, with fairly fine entrance and exceedingly fine run aft, carried on continuously curving lines throughout, could be driven at a higher rate of speed with a less expenditure of power than a long and narrow ship of the same capacity with fine entrance and parallel-sided body. Probably the greater amount of skin friction in the latter vessel might account for this result, but the relation of the resistances arising from this, and from the generation of waves in deep water, to the shape of the ship, at different speeds, still requires some elucidation.

The City of Rome is 600 feet long over all, with an extreme breadth of 52 feet and depth of hold of 37 feet. Her midship cross-section on 26 feet draught is about 1300 square feet, and her displacement at that draught 13,500 tons. The indicated horse-power of the engines exceeds 14,000. The

America is 459 feet in length (extreme) and 51 feet in breadth, and her depth amidships is 38½ feet. On 26 feet draught her cross-section is 27 square feet less than that of the City of Rome, and her displacement is 8830 tons. The former vessel averages 16 knots on a coal expenditure of over 300 tons per day, while the America averages 18 knots on a consumption of 180 tons per day.

With a length between perpendiculars of 432 feet and a beam of 51 feet, the America has a depth amidships to the upper deck of 38½ feet, and to the promenade deck of 47 feet. The promenade deck is 250 feet long; and, if it were continuous throughout, or made so that the strains could be transferred by suitable struts and ties, the vessel might be considered as a girder, with upper and lower chords 47 feet apart; but, as it is, she is treated by the builders as a beam of but 38½ feet depth, and they have used steel with a compressive strain of 32 to 36 tons per square inch above the neutral axis, and of 29 tons below it. The material throughout is mild steel. There are three decks continuous throughout the vessel: the upper deck; the main deck, at 29½ feet, and the lower deck, 21¼ feet above the bottom of keel; while an orlop deck is fixed at 13½ feet wherever the arrangement of machinery permits. The frames are spaced 27 inches, and the flooring beams 54 inches apart, and two rows of stanchions are placed under beams wherever practicable. Extremely strong web frames and reverse frames are carried through the machinery rooms; and four keelsons on each side of the centre keelson suitably stiffen the vessel longitudinally. The plating varies in thickness from ⅝ to ¾ inch, butt-strapped and treble-riveted. Eleven water-tight bulkheads, carried to the upper deck, divide the ship into 12 compartments, the longest of which does not exceed 48 feet; and any two of these may be filled with water without sinking the vessel. The bulkheads are from five to seven-sixteenths of an inch in thickness and are well stiffened. Three coal bunkers carry together 1650 tons of coal.

The engines of the America are direct-acting, with one high-pressure cylinder of 63 inches diameter, and two low-pressure, each 91 inches diameter, with 66 inches stroke. Each cylinder has four piston valves, coupled two and two above and below—the high-pressure of 25 inches diameter and 9 inches stroke; the low, 32 inches diameter and 12 inches stroke. The steam enters from the boilers at 90 pounds pressure and passes from the high-pressure cylinder to the reservoir at about 26 pounds pressure, whence it is taken through the low-pressure cylinder, expanding, to the condensers, where a vacuum of 26 inches is easily maintained by the air-pumps and the action of two Gwynne's pumps, throwing from four to five thousand tons of water per hour through the condensers. These are worked by separate engines of about 40 indicated horse-power. The total tubular surface in the condensers is about 12,000 square feet. Two air-pumps, of 36 inches diameter and 33 inches stroke, are worked by the main engines. The estimated power of the engines is over 7000 horse-power. Six double-ended boilers, 17½ feet long and about 14 feet diameter, produce steam at 90 pounds pressure, while an extra single-ended boiler, 11 feet long and 15 feet diameter, furnishes steam at 95 pounds pressure. The total grate surface of the seven boilers is 883 square feet; the tubular surface about 21,000 square feet. The total weight of the boilers is about 333 tons, and they are constructed of steel plating from $\frac{15}{16}$ to 1 inch thick. Each boiler carries three safety valves of 5¾ inches diameter, all inaccessible. Two oval-shaped funnels, each divided longitudinally by a diaphragm, rise 100 feet above the keel of the ship. The engines are provided with Dunlap's governor, and special starting-gear, arranged so that the speed can be adjusted independently of the governor. It is found that 65 to 66 revolutions of the engine give a speed of about 18 knots through smooth water, while 68 to 70 carry the vessel at about 19 knots. The crank shafts are of steel. The propeller shaft is of forged scrap-iron, 36 feet long and 22 inches diameter. The thrust is carried by ten collars, with about 3000 square inches of bearing. The propeller is four-bladed, 22 feet in diameter. The leading side has a regular pitch of 29 feet;

the following side a pitch varying from 24 to 34 feet. The blades are of manganese bronze; the boss is of steel. The weight of the former is about 15 tons; of the latter, about 9 tons with the bolts. The total surface of the four blades is 164 square feet. The between-deck spaces are connected with ventilating tubes which terminate in the chimneys. A complete system of drainage from the cabins, decks, and bilges is made by pipes and pumps worked by the engines.

P. F. H.

THE LUNAR SURFACE AND ITS TEMPERATURE.

In *Nature*, impression of July 15, 1886, there is a very interesting discussion of this subject by John Ericsson. The paper will be found also in the *Scientific American* supplement of August 14, 1886. The writer rejects the hypothesis of a volcanic origin of the walls of the great "ring mountains" of the lunar surface, and argues that they are inert glaciers which have become as permanent as granite mountains by the action of perpetual intense cold.

Discussing the maximum temperature which solar radiation is capable of imparting to the lunar surface, it is proved that when the earth is in aphelion the temperature of the lunar surface when presented to the sun can only be augmented 81.11° F. Captain Ericsson has devised a pyrheliometer, by means of which he has shown that the moderate heat produced by solar radiation is capable of increasing the temperature of bodies, previously heated to a high degree, by an amount which depends upon the intensity of the sun's rays. Regarding the temperature prevailing during the lunar night, its exact degree is not of vital importance in establishing the glacial hypothesis, since the periodical increment of temperature produced by solar radiation is only a fraction of the permanent loss attending the continuous radiation against space resulting from the absence of a lunar atmosphere; besides, all physicists admit that it is extremely low.

The formation of annular glaciers by the joint agency of water and the internal heat of a planetary body devoid of an atmosphere and subjected to extreme cold is readily explained on physical principles. Suppose a sheet of water on the moon's surface covering the same area as the plateau of Tycho—viz.: 50 miles in diameter and 1960 square miles in area. Suppose, also, that the internal heat of the moon is capable of maintaining a moderate steam pressure, say 2 pounds to the square inch, at the surface of the water in the pond. The attraction of the lunar mass being only one-sixth of terrestrial attraction, while the moon's surface is freed from any atmospheric pressure, it is evident that under the foregoing conditions a very powerful ebullition and rapid evaporation will take place, and that a dense column of vapor will rise to a considerable height above the boiling water. It will also be evident that the expansive force within this column, at the surface of the water, will be so powerful at the stated pressure that the vapor will be forced beyond the confines of the pond in all directions with great velocity. No vertical current, it should be understood, will be produced, since the altitude of the column, after having adjusted itself to the pressure corresponding with the surface temperature of the water, remains stationary, excepting the movement consequent on condensation from above. The particles of vapor forced beyond the confines of the pond, on being exposed to the surrounding cold, caused by unobstructed radiation against space, will crystallize rapidly, and in the form of snow fall in equal quantity round the pond, and thereby build up an annular glacier.

Captain Ericsson discusses other features of the moon's surface, with the causes of formation, in this most interesting and instructive essay.

P. F. H.

ON BANKED FIRES.

[Translated from *Die Schiffsmaschine* by W. F. WORTHINGTON, P. A. E.]

It is a widespread error to suppose that banking fires, especially in large boilers with large water spaces, even for two or three days at a time, is more economical than hauling fires and starting them again.

By referring to the accompanying table, in which are given data collected from the ships named, it is seen that the amount of coal required to keep banked fires in large boilers for about 20 hours, and in small ones for about 30 hours, is equal to the amount required to start the fires.

The quantity of fuel required to heat the water is not considered, because it is about the same in either case. From the table it is seen that with banked fires the weight of coal per furnace per hour is, for small boilers, 16 to 18 pounds; medium, 22 to 24 pounds; large boilers, 26 to 31 pounds; and for starting fires it requires on an average, in round numbers, from 21 to 25 pounds per square foot of grate. Taking into consideration that banking fires is only economical when the period for which the engines are to be stopped does not exceed about 24 hours, and that even in this case the life of the boiler is much shortened, we must conclude that fires should never be banked for more than a few hours except when anchored in an unsafe harbor, or in such cases where the exigencies of the service may require the use of the engines at very short notice.

EXTRACT FROM TABLE IN "DIE SCHIFFSMASCHINE."

Name of Vessel.	I. H. P. of the Engines, Approximately.	Average weight of coal required in pounds.				Number of hours in which the amount used under banked fires becomes equal to amount required for starting fires.	Remarks.
		For starting fires.		Under banked fires.			
		In all furnaces	Per sq. ft. of grate.	For all fires for 24 hrs.	For one fire per hour.		
König Wilhelm	8000	22,047	24	26,456	28	20.0	The banked fires are kept in condition to raise steam at half an hour's notice.
Kaiser and Deutschland	8000	26,456	30	30,865	32	20.5	
Kronprinz	4800	17,640	24	19,845	26	21.3	
Friedrich Carl	3500	13,230	23	22,047	35	14.4	
Preussen	5400	13,230	19	19,845	28	16.0	
Friedrich der Grosse	5400	16,537	24	22,047	31	18.0	
Sachsen and Class	5600	22,047	30	21,168	28	25.0	
Leipzig and Class	4800	17,640	28	15,432	23	27.4	
Bismarck and Class	2500	8,820	23	10,584	22	20.0	
Hertha and Vineta	1500	7,938	28	8,820	23	21.6	
Mars	2000	12,127	28	10,584	22	27.5	
Ariadne and Louise	2100	7,717	29	7,716	23	24.0	
Nymphe	800	3,969	30	3,306	17	28.8	
Zieten	2350	6,615	28	4,409	15	36.0	
Loreley	350	1,654	24	2,117	22	18.7	
Habicht and Möwe	600	2,646	25	1,764	18	36.0	
Albatross and Nautilus	600	2,646	23	2,205	15	28.8	
Wolf and Class	340	1,654	28	1,587	17	25.0	

W. F. W.

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MAY. Notes on the method of compiling a range-table, by Commander H. J. May, R. N. The trajectory for the cubic law of resistance, by A. G. Greenhill, M. A. The march of the right division Hazara Mountain Battery, by Lieutenant A. H. C. Birch, R. A.

JUNE. Short history and description of armor and its attack by artillery, by Captain Orde Browne (late R. A.) Vertical fire in the field, and how the question is regarded in Russia, by Captain E. S. May, R. A. Shield or shelter, by Major T. B. Tyler, R. H. A. Extracts from the "History of the Royal Artillery," by Lieutenant-Colonel Jonas Watson. A simple method of range-finding from coast batteries when in signaling communication with each other, by Colonel Stapleton Penny, R. A.

JULY. The volunteer field battery, Bechuanaland field force, by Major E. A. Ollivant, R. A. Report of experiments with Nordenfelt's submarine boat, by Lieutenant J. H. Thomson, R. H. A. Remarks on fortification, by Lieutenant C. E. Callwell, R. A. The general arrangement and practical working of the artillery defense of a first-class fortress protecting a harbor and dockyard (the gold-medal prize essay), by Major A. W. White, R. A.

AUGUST. Proposed system for checking the recoil of field guns, by Lieutenant F. R. Maunsell, R. A. Extracts from the diary of Captain Pococke, 71st Highland Regiment, while a prisoner in Buenos Ayres, 1806–1807; contributed by Lieutenant-Colonel Duthie (late R. A.). Use of portable rails; moving two 38-ton guns on portable rails to Colaba Point Battery, by Colonel Stapleton Penny, R. A. Arming the *personnel* of horse and field artillery, by Captain E. A. Lambart, R. A. The general arrangement and practical working of the artillery defense of a first-class fortress protecting a harbor and dockyard (the silver-medal prize essay), by Major R. W. Rainsford-Hannay, R. A. The commended essay, same subject, by Captain E. Nash, R. A. On the rejection of abnormal rounds in trials for accuracy of shooting, by Major H. W. L. Hime, R. A.

SEPTEMBER. Précis of Lydd experiments, 1882–3, by Colonel F. G. Baylay, R. A. Landing the 110-ton b. l. gun at the Royal Arsenal, Woolwich, by Col. J. T. Barrington. Artillery, a review, by Captain J. M. Grierson, R. A.

UNITED STATES ARTILLERY SCHOOL.

ARTILLERY EXERCISES.—CLASS A. Description and service of machine guns, Gardner gun, Hotchkiss revolving cannon, Hotchkiss 1.65-inch b. l. mountain gun. The 0.45-inch Gatling guns, old and new models, by Captain John H. Calef, Second Artillery. Notes on experiments with high explosives, Fort Monroe, Virginia, May, 1886, by M. M. Macomb, First Lieutenant Fourth Artillery. Comparisons of the armaments of European nations, describing their systems of artillery, by A. D. Schenck, First Lieutenant Second Artillery. Notes on the distribution of iron ores in the United States, compiled from various geological reports, by Anthony W. Vogdes, First Lieutenant Fifth Artillery.

The following essays: Defensive and offensive weapons and engines of the ancients and of the Middle Ages; their relation to the constitution and handling of armies, and their effect upon the art of war, by John R. Williams, First Lieutenant Third Artillery. An historical account of the development of small arms and ammunition for the same, and the effect of the same upon the science of war, by Charles A. Bennett, Second Lieutenant Third Artillery. Military Geography of the Dominion of Canada, by A. D. Schenck, First Lieutenant Second Artillery.

By the author: Report on the Grand Manœuvres of the Seventeenth Corps of the Army of France, by First Lieutenant John P. Wisser, First Artillery, Vancouver Barracks, W. T.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

The field telegraph, its use in war and its employment in the late expeditions in the Soudan and South Africa, by Major C. F. C. Beresford, R. E. The defense of London and of England. Part I. The security of London against a *coup de main*. Part II. The successive stages of the defense, by Major H. Elsdale, R. E. The defense of the coasts of England, Ireland and Scotland in the event of war, by Rear-Admiral W. Arthur, C. B. Mounted Infantry, by Major E. T. H. Hutton, King's Royal Rifles. A Reserve of Horses, by Colonel F. G. Ravenhill, R. A. To find the deviation of a rifle-bullet due to the rotation of the earth, by J. H. C. Dalton, B. A.

R. R. I.

LITERATURE OF EXPLOSIVES.

INDEX TO PART I., by Charles E. Munroe, S. B. (Harv.). Printed and sold by Friedenwald, Baltimore, Md.

AMERICAN ACADEMY OF ARTS AND SCIENCES.

PART II., FROM OCTOBER, 1885, TO MAY, 1886. This valuable number contains:—XXIII.: Measurement of the strength of telephone currents, by Chas. R. Cross and James Page.

A form of electrical balance similar to that figured by Maxwell (*Electricity and Magnetism*, 2d Ed., Vol. II, 342) was at first constructed, but this failed to

give satisfactory results. Subsequently success was obtained by using a Kohlrausch unifilar electro-dynamometer, made by Hartmann, of the form described by *Wiedemann's Annalen*, Vol. XV, 1882, p. 550. Measurements were made with the Hunning, Fitch, Blake, Edison and Bell magneto transmitters. The Hunning transmitter uses carbon in a granulated form, and the Fitch employs two hard carbon discs as electrodes. The vowels *a*, *o*, *u*, *i* (German sounds) were spoken or sung into the transmitter successively, all at the same pitch—viz.: the *B* of 480 vibrations—and with the same intensity, as nearly as this could be realized. The deflections obtained are given in full in readings in centimetres and tenths. Several series are given. Very interesting results were obtained.

XXIV. Experiments with the thermal telephone, by Chas. R. Cross (Rogers Laboratory of Physics).

XIV. Early experiments in telegraphing sound, by Edw. C. Pickering.

XV. and XVI. Atmospheric refraction, by Edw. C. Pickering.

XVII. A new form of polarimeter, by Edw. C. Pickering.

XX. Observations of variable stars, 1885, by Edw. C. Pickering.

XXI. On the methods of study of thunderstorms, by W. M. Davis.

A very important paper detailing the methods of systematic study of thunderstorms in France, Norway, Russia, Belgium, Italy, Bavaria, Netherlands, Saxony, Central Germany, Switzerland, and by the United States Signal Service. In the discussion of observations the author gives a simple and ingenious method of portraying storms.

XVIII. A new logical machine, by Allen Marquand, Ph. D.

XXII. The dynamic action of an electric current, by Hammond Vinton Hayes.

XXIII. On conditions that determine the length of the spectrum, by Amos E. Dolbear.

J. W. D.

AMERICAN GEOGRAPHICAL SOCIETY BULLETIN.

No. 1, 1886. Mountaineering in British Columbia, by Ernest Ingersoll. Persia and the Persians, by S. G. W. Benjamin, Ex-Minister to Persia. Geographical notes, by Geo. C. Hurlbut.

AMERICAN IRON AND STEEL ASSOCIATION.

CORRECTED TO JULY 15TH, 1886. Directory to the iron and steel works of the United States, embracing the blast furnaces, wire mills, pipe works, etc.

Nos. 20 to 35 (both inclusive) contain much useful information about the metals.

"Twenty-one Years of Progress in the Manufacture of Iron and Steel in the United States," by James M. Swank, General Manager American Iron and Steel Association (conclusion).

"It has been the object of this paper to exhibit the astonishing progress of the United States in the manufacture of iron and steel in the last twenty-one years, and to show the prominence of our country as a producer of these essen-

tial aids to modern civilization. With an abundance of good ores and good fuel, including under the latter head our great stores of natural gas, we must soon become the first iron and steel-producing country in the world, as we have long been the largest consumer of these products. Only Great Britain excels us in the production of pig iron and steel, but we annually consume more of each product than our great rival. We consume to-day one-fourth of all the pig iron and one-third of all the steel that the world produces."

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, TRANSACTIONS OF.

VOL. VII, 1886, is a valuable contribution to engineering literature, containing: The President's Address for 1885. The basic Bessemer process. Rapid transit and elevated railroads. Twist drills. The frictional resistance of shafting in engineering establishments. The unexpected which often happens. The microscope in the workshop. A new form of steam calorimeter. Improvement in ferryboats, by Wm. Cowles, member U. S. N. I. The rating of steam boilers by horse-powers for commercial purposes. Crystallization of iron. Experiments on the transmission of power by gearing. Standard pipe and pipe threads. Steam-engine tests at Massachusetts Institute of Technology. The course in mechanical engineering at Massachusetts Institute of Technology. Notes on the comparative value of metal surfaces for warming air. Topical discussions. The engineer as an economist. Another new steam indicator. The production of true crank shaft and bearing. Substitutes for steam. The relative efficiency of centrifugal and reciprocating pumps. The engineer as an economist, by H. R. Towne, member U. S. N. I. The training of a dynamic engineer in Washington University, St. Louis.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, THIRTEENTH MEETING AT CHICAGO.

The production of true crank shafts and bearings, by Horace See, member U. S. N. I., Philadelphia, Pa., Supt. Engineer of Wm. Cramp & Sons, S. & E. B. Co.

This paper describes the plan by which the shafts of the steamships Mariposa, Alameda, San Pablo, H. F. Dimock, Eureka, El Paso, El Dorado, Philadelphia, and yacht Atalanta, were fitted. "Some 25,000 nautical miles have been run before readjustment has been necessary, and 135,000 before wear of journal and bottom box combined amounted to the one-fiftieth of an inch."

AMERICAN PHILOSOPHICAL SOCIETY.

VOL. XXIII, JULY, 1886, No. 123. The glaciation of parts of the Wyoming and Lackawanna Valleys. Composite photography applied to handwriting. The use of oil in storms at sea. And several other scientific papers.

CANADIAN INSTITUTE, TORONTO, PROCEEDINGS OF.

VOL. XXI, JUNE, 1886, No. 145. Goldmining in the Saskatchewan, by Chas. Levey. Extinct cuttle-fish in the Canadian Northwest,

by A. McCharles. The alimentary canal in ganoid fishes, by A. B. Macallum, B. A. Ancient Egyptian language, by Rev. George Burnfield.

CITY RECORD, OFFICIAL JOURNAL, NEW YORK.

JUNE 28, 1886. Preliminary report on the progress made in paving Fifth Avenue, by Colonel George T. Balch, member U. S. N. I.

SEPTEMBER 28, 1886. Contains (pages 2299 and 2300) report of Colonel George T. Balch. Where the responsibility lies for the "violation of the law and the contract described in this report" (Repaving of Fifth Avenue). J. W. D.

TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

APRIL–JULY, 1886. The South Pass jetties. The spongilla in main pipes. On the accuracy of a system of magnetic bearings of a survey. Mexican bridge construction. Excavation and embankment by water power. Permanent transmitting dynamometer. Data for flattening the ends of railroad curves. On cranes as labor-saving machines. Thermometer scales. The steamship America. On specifications for strength of bridges. On the strength of columns. New formula for compression members. P. F. H.

BULLETIN DE LA RÉUNION DES OFFICIERS.

No. 34, AUGUST 21, 1886. On military schools in Germany. Application of the telephone in war (illustrated).

No. 35, AUGUST 28, 1886. Completion of article "The Telephone in War."

No. 36, SEPTEMBER 4, 1886. Extract from *La Spezia* on experiments with a 100-ton Armstrong gun against armor plates. Trials of April 20, 24 and 29, 1886, at Spezia, Italy.

No. 39, SEPTEMBER 25, 1886. Commissariat service in the Austro-Hungarian Army; also, the preparatory school for cavalry in France.

No. 40, OCTOBER 2, 1886. New campaign stove (illustrated). Supplying ammunition on the field of battle, as in the Austro-Hungarian Army. Repeating rifles; with extracts from a book written by M. Hebler on "The Least Calibre; or, the Coming Rifle for Infantry Use." D. H. M.

JOURNAL DU MATELOT.

No. 27, 1886.

During the survey of the New Hebrides archipelago the French ship Dives discovered, on the 30th March, an excellent anchorage, in the island Urèparapara, into which no vessel had ever been. It was carefully surveyed and named Dives Bay in compliment to the ship.

No. 39, 1886. An account of an electric-lighted life buoy for men-of-war or other vessels fitted with dynamo machines.

The light of this buoy can be also used for a stern light, when Article 11, Rules of the Road, has to be complied with. D. H. M.

MECHANICAL ENGINEER.

JUNE 26, 1886. The U. S. S. Puritan.

Cross-sections through the pilot-house of new and old Puritan are given, and table showing that the new ship compares favorably with the Conqueror and Tonnerre.

Description and drawings of the novel and ingenious ash-hoist engine of the U. S. S. Atlanta.

JULY 10, 1886. List of dry-docks of the United States exceeding 58 feet breadth of entrance:

Port.	Kind of Dock.	Dimensions of Dock.			Dimensions of Largest Vessel that can be taken in.			
		Length over all.	Width of entrance.	Depth on sill, spring tides.	Length.	Beam.	Draught.	Tons.
		Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	
Buffalo	Basin	350	60	10	...	...	...	...
Detroit	Basin	308	65	13	...	...	...	2000
Detroit	Basin	360	75	11.5	...	...	...	2000
Albina, Oregon	Basin	400	72	28	...	...	...	...
San Francisco	Floating	210	60	20	...	...	...	1500
San Francisco	Basin	450	90	24	438	...	...	...
San Francisco	Basin	529	78	26.5	460	78	27.5	9000
Portland, Me	Basin	425	80	24	...	...	18	...
Portsmouth, N. H.	Floating	350	90	23	350	90	23	5300
Boston	Basin	379	60	25	354	60	25	8000
Boston	Basin	365	64	17.5	352	64	17.5	...
Brooklyn	Basin	350	66	25	350	66	25	7500
Brooklyn	Basin	540	100	22	510	70	22	...
Brooklyn	Basin	630	85	25	567	56	25	...
New York	Balance	330	90	18.5	...	...	...	...
New York	Sectional (10)	360	100	20	400	95	19	6000
New York	Sectional (8)	250	75	16	...	...	14	3000
New York	Sectional (6)	170	65	16	...	...	14	1500
Jersey City	Balance	185	62.5	14	...	...	...	1200
Philadelphia	Basin	434	70	21.5	425	55	21.5	...
Philadelphia	Sectional	200	62	14	...	...	...	2300
Baltimore	Basin	504	80	23	450	...	...	...
Baltimore	Floating	220	67	14	...	...	...	2000
Norfolk	Basin	320	60	...	290	60	...	7000
New Orleans	Floating	315	90	16	330	42	16	3000
New Orleans	Floating	220	75	14	230	...	...	1400
New Orleans	Floating	225	75	16	...	...	..	...

JULY 24, 1886. Notice of the Herreschoff launch Henrietta.

Length on water-line, 46 feet by 7 feet 5 inches beam; immersed section, 7½ square feet. Engine, triple-expansion; cylinders, 4, 6½ and 10 inches diameter by 8-inch stroke; steam pressure, 250 pounds. Screw, four-bladed, 28 inches diameter. Weight of vessel in running order, 10,000 pounds. Speed, 20 miles per hour, mean of six trials over measured mile.

AUGUST 7. General plans and specifications of a lake and a light-draught harbor defense boat, designed by Assistant Constructor Gatewood, U. S. N.

SEPTEMBER 4. General plans and specifications of a 19-knot cruiser designed by Armstrong and Mitchell.

SEPTEMBER 18. General plans and specifications of a first-class ironclad for service in open bays and deep channels, designed by Assistant Constructor Gatewood, and recommended by the "Board on Fortifications."

OCTOBER 2, 1886. General description of machinery of U. S. S. Newark.

The Herreschoff launch Henrietta made the trip from Newburg, N. Y. to Sandy Hook, N. J., at 20.8 miles per hour.

OCTOBER 30, 1886. Sketch and description of the boilers of the Naniwa-Kan. W. F. W.

GIORNALE D'ARTIGLIERIA E GENIO. General orders, decrees, working drawings.

No. IV, 1886. Artillery percussion fuses.

No. VI, 1886. Muskets of the various arms, model of 1870.

RIVISTA DI ARTIGLIERIA E GENIO.

APRIL, 1886. Hotchkiss, Nordenfelt, and Armstrong rapid-firing guns. Ballistic tables. Experiments at Bucharest in December and January, 1885-6, with a Mougin turret and a Schumann cupola (complete illustrations). Mining experiments with nitroglycerine. Electric engines at the Turin Exposition. Electric small-arm targets for signaling position of hits.

MAY, 1886. The artillery in the Servo-Bulgarian campaign. Experiments at Spezia in April, 1886, against a Grüson turret plate.

JUNE, 1886. Translation of Gun Foundry Board Report, concluded. Nitroglycerine experiments. Electricity at the Turin Exposition. Armor-plate experiments.

New truck or carriage for heavy weights:

The track is a loosely-jointed periphery outside the wheel, and is joined to the hub by slotted spokes; it is laid in advance and picked up in rear of the wheel by movement of the carriage.

JULY–AUGUST, 1886. The attack and defense of forts. Discovery of an autograph letter of Galileo in regard to the use of mathematics in the military arts. Spezia experiments in April, 1886, with a Grüson plate. Complete maps of the French fortifications on the Italian frontier.

SEPTEMBER, 1886. The use of sugar to prevent scale in boilers.

Supplement to the above publication. "Manuale Regionato del Laboratorio di Precisione," E. Morandotti, Major of Artillery: a pamphlet of 157 pp. and 23 plates, giving details of the use of precise instruments of measurement in artillery workshops.

RIVISTA MARITTIMA.

MAY, 1886. The cruise of the Vettor Pisani (navigation notes, Valparaiso to Callao). The Italian Navy Estimates, continued in numbers for June, July–August, September.

JUNE, 1886. The cruise of the Vettor Pisani (navigation notes, Callao to Guayaquil). Theory of high and low atmospheric pressures.

JULY–AUGUST, 1886. Official statistics of the Italian merchant marine.

On the 31st December, 1885, there were:

Sailing vessels	7111	of	828,819 tons.
Steamers	225	"	124,600 "
Total	7336	"	953,419 "

Personnel of all kinds, 192,046.

For the year before there were:

Sailing vessels	7072	of	848,704 tons.
Steamers	215	"	122,297 "
Total	7287	"	971,001 "

Personnel, 189,162.

SEPTEMBER, 1886. The cruise of the Vettor Pisani (navigation notes, Callao to Panama and the Galapagos Islands). R. C. S.

ASSOCIATION OF ENGINEER SOCIETIES.

Journal for JUNE, 1886, contains: The efficiency of a pipe system for furnishing water to fire-engines. Smoke prevention.

JULY, 1886. President's annual address. Organization of a surveying party. The metre as applied to land-surveying.

AUGUST, 1886. Notes on the Panama Canal, by Chas. D. Jameson, member of the Boston Society Civil Engineers.

A complete account, containing plan and profile of canal, and much statistical information, with many important details. He concludes as follows: "There are no insurmountable obstacles in the way of the completion of the Panama Canal in a few years. . . . The management of the Isthmus has been loose and

disjointed, but it is rapidly improving. Undoubtedly money has been wasted, but no greater percentage than in other large enterprises. The work is being pushed in every direction. Contractors are being held to their contracts, and although no one can state the time when the canal will be finished, still no one can advance the proof why it cannot be finished within the next eight years."

SEPTEMBER, 1886. Rainfall received and collected, etc. Some of the engineering features of Illinois drainage. Foundations of the Garfield Monument. J. W. D.

INSTITUTION OF CIVIL ENGINEERS, LONDON.

VOL. LXXXV, 1885–86, Part III.

VOL. LXXXVI, 1885–86, Part IV. Contains many important and interesting papers, among which are: On the effects of various kinds of liquids, hot and cold, on iron, for preserving it from corrosion. On the employment of iron and steel in construction. The Isthmus of Corinth Canal. Regulation of the Elbe navigation, harbor of Reunion Island. On the rate of detonation in solid and liquid explosives (translated from M. Berthelot). New ordnance material (Captain W. H. Bixby, U. S. A.). Experiments on the steam-engine indicator. Navigation by night on the Suez Canal. A new tubular compass.

LANCASTER PRINT, No. 9. U. S. S. Lancaster, Island of St. Helena, July 11, 1886.

An interesting paper published on board ship and giving important details of ship news, of places visited, with poetic and prose effusions, forming quite a diverting and educational employment beneficial in many ways during a long cruise. J. W. D.

REVUE MARITIME ET COLONIALE.

JUNE, 1886.

In a circular order dated May 20, 1886, and published in this number of the *Revue*, the Minister of Marine directs that all articles intended for publication in the *Revue Maritime et Coloniale* shall be sent directly to the Minister of Marine, instead of being submitted to local commissions of officers. This action is taken on account of a falling off in the number and character of the articles submitted for publication in the *Revue*.

Contents: The Armstrong 6-inch cannon, pattern of 1883. The bursting of the 12-inch cannon of 43 tons on board the Collingwood, May 4, 1886. Quadruple-expansion marine engines.

JULY, 1886. The Italian merchant marine. Launching of the Danish armored vessel Iver-Hvitfeldt. Trial of the 100-ton Armstrong gun against steel plates at Spezia. Inauguration of the high-speed postal service between Paris, Havre and New York.

AUGUST, 1886. The Spanish Navy and its reorganization in June, 1886. Submarine navigation.

SEPTEMBER, 1886. The port of La Ciotat.

The Orlando, English belted-armored cruiser, the first of seven of the same type, was launched August 3, 1886, at the dockyard of Palmer & Co., Yarrow-on-the-Tyne. The principal dimensions of this vessel are: Length, 300 feet; breadth, 56 feet; draught, 20 feet. The total displacement is 5000 tons, with engines of 9000 horse-power. The speed is expected to be 19 knots.

OCTOBER, 1886. Manœuvres of the English squadron in 1886. The English armored vessel Impérieuse. The English gunboats Curlew and Landrail. Armstrong cannons.

UNITED SERVICE GAZETTE.

JULY 31. Description of the new torpedo cruiser Destructor, built by Messrs. Jas. and Geo. Thomson, Clydebank, for the Spanish Navy.

AUGUST 7. Account of recent manœuvres of the French fleet in the Mediterranean.

AUGUST 21. Naval operations at Milford Haven. Fatal accident on board the Opal in firing a salute.

AUGUST 28. Gunnery experiments at Portsmouth.

SEPTEMBER 4. Account of trial of H. M. S. Impérieuse.

SEPTEMBER 11. Report of Ordnance Committee on the bursting of a 12-inch breech-loading gun on board the Collingwood, May 4, 1886.

SEPTEMBER 18. Account of experiments with submarine mines, made at Portsmouth, England, by direction of the Admiralty.

SEPTEMBER 25. Increase of the French Navy.

Dating from 1872, the French have added to their Navy twelve squadron ironclads, seven cruising ironclads, eight coast-defending armor-plated vessels, seven turret ships, nine first-class cruisers and eight of the second class, together with 227 smaller craft, including dispatch and gunboats. There are to be added to the French fleet between this date and the first of the coming year six squadron ironclads, four barbette ships, two turret ships, and three cruisers of the first class. The ironclads will carry guns from 14 to 42 centimetres, which are described as most formidable weapons. It is stated, however, that the cruisers are slow sailers, and that considerable improvement must be made in their engines to fit them for the requirements of modern naval warfare. None of the ironclads can sail 15 knots per hour, and only one of the reputed fast-sailing cruisers can do 18 knots per hour. The French are now turning their attention to the subject of increased speed in their Navy, and much is expected to be done in this direction before the next naval estimates are submitted to the Chamber.

Torpedo experiments of a purely naval character have recently been made at Portsmouth, England. This, it is said, is the first instance of a Whitehead torpedo having been exploded against the hull of a ship. Hitherto their destructive effects have been purely a matter of assumption. The present experiments are calculated to settle any practical questions of attack and defense connected with a torpedo attack which demanded a solution. The experiments were made upon the Resistance, obsolete armorclad, and several things were required to enable her to represent a modern battle-ship attacked under

approximate conditions. The bunkers below the armor-shelf on the port side were made to represent the actual coal defense which is now applied for the protection of the boilers and machinery of a ship-of-war against submarine attack. The bunkers were fitted at Devonport with an iron longitudinal bulkhead, which divided them into two equal compartments. The one contiguous to the skin plating was filled with coal, due precautions being taken against firing by the provision of ventilating tubes. By these means there was a thick protection of coal sandwiched between the inner bunker and the wing passage. The whole port side of the ship was also defended against torpedo attack by Bullivant's service wire nets, boomed out to the distance of 30 feet. This was a distance which previous trials had abundantly proved to be safe against the destructive force of a Whitehead; but the weight of such booms, and the necessary working gear, renders them unhandy, and the main object of the experiment was to ascertain whether the length of the boom could be reduced without danger to the vessel attacked. In actual warfare it is presumed that the burst of a Whitehead would prove fatal to a ship, wherever it came in contact with her; but in this case it was imperative that the Whitehead should hit her, not anywhere, but directly in a certain compartment about 29 feet in length and extending from the keel-flat to the armor-shelf amidships. To insure accuracy, therefore, the vessel was chained stem and stern. The time of high water was chosen for the experiment, so as to avoid the deflective influence of currents. The instrument of execution selected was the old 16-inch Whitehead. The full charge of this old weapon is 91 pounds of gun-cotton, and the full charge for the new 14-inch Whitehead is only 65 pounds. The torpedo was fitted with the new pistol trigger, which is exceedingly sensitive, and explodes the charge upon traversing the meshes of the net. The effective range of the improved Whitehead is 600 yards, but in this instance it was expedient to attack the net defenses of the Resistance at close quarters, and therefore the projectile was discharged by the torpedo vessel when passing the Resistance at a distance of 100 yards. The path of the torpedo through the water was clearly indicated by the air-bubbles which it threw up, and though straight, its progress was undeniably deliberate. The torpedo struck the defenses a little forward of the target, but though the visual force of the explosion was very great, the vessel does not seem to be seriously injured. As soon as the fountain of water which had been thrown up had subsided, it was manifest that the netting had served the intended purpose. The nearest boom had been unshipped from its support, but all the others remained intact. The meshes in the immediate vicinity of the burst had been carried away, but the area of positive destruction was so small that a second attack would have proved just as harmless, unless the torpedo happened to pass through the rent in the defenses made by the first. Two other experiments were made, both with 16-pound cases of gun-cotton, to ascertain the effect of small charges of gun-cotton on the ship itself. As a result the ship appeared to give a list to port, and tugs stood by to pump her out in case she had sprung a leak. She was afterwards found to leak very badly, and the experiments were discontinued.

The torpedo flotilla of the Royal Navy has received, lately, a number of additions by the delivery of a large number of first-class torpedo vessels from the contractors. The Admiralty have issued instructions for these vessels to be at once completed for sea and placed in the first-class reserve, in readiness for sea service. A first-class torpedo boat built by Messrs. Thornycroft, 125 feet long and 16 feet wide, recently made a run down the Solent into the open channel for a distance of forty miles. This run was made with favorable wind and tide in one hour and thirty-eight minutes, and the return trip of forty miles was made against the tide and a strong wind in one hour and fifty-six minutes. The bow-wave thrown up by the snout of the torpedo boat was from 10 to 15 feet high. It is thought that the present shape of the bow and the creation of the wave will affect the accurate discharge of the torpedo from the nose of the vessel, and changes in the mode of discharge are contemplated.

OCTOBER 2. Account of experiments with a new French explosive. A new torpedo invented by Louis Brennan, an Australian civil engineer. The Spanish Navy.

A committee has been ordered to assemble at Portsmouth to consider the whole subject of voice, mechanical and electrical communication between the deck and engine room of men-of-war.

The Unebi, a cruiser constructed at Havre by the Société des Forges et Chantiers for the Japanese Government, recently made her trial trips at Havre and Cherbourg. She attained a mean speed of 18½ knots, one knot over the requirements of the contract. The armament of the Unebi consists of four 24-centimetre guns, seven 15-centimetre guns, and a large number of machine guns. Besides the above armament, the vessel has four torpedo-launching tubes constructed of bronze on the system of M. Canet.

OCTOBER 9. The late Admiral Bedford Pim.

OCTOBER 16. The report of a committee appointed to inquire into the education of naval executive officers.

The dockyard authorities at Portsmouth have received instructions to take the whole of the new Thornycroft torpedo boats in hand, with a view to making them more buoyant, and consequently increasing their speed. At present the boats plunge into every wave they meet, and the weight of the water thus resting at the bows renders the forward torpedo tubes useless, whilst the boats are constantly swamped. The structural alterations will necessitate the removal of the bow tube, and the boat will thus fire only four torpedoes instead of five. Torpedo boat No. 42, one of the latest of the 125-feet first-class boats, is having her tapering snout removed, and the bows brought up level with the deck, the same as the boats of the Yarrow type. When this alteration is completed it is intended to run her in competition with one of White's torpedo boats.

A trial has been made of Nos. 55 and 56, torpedo boats of the first class, built by Thornycroft & Co. Trials over the measured mile gave the following results: No. 55—steam in boilers, 132 pounds; vacuum in condensers, 27 inches; revolutions of engines, 402; speed, 20.35 knots. No. 56—steam in boilers, 132 pounds; vacuum, 27 inches; revolutions of engines, 399; speed, 20.22 knots.

The Impérieuse has returned to England from an experimental cruise to the Mediterranean. Her captain reports that she is a capital steamer, and is so free from vibration that when going at a speed of nine knots, the working of the engines was scarcely appreciable. She proved herself remarkably steady, rolling only 1¼ degrees in the trough of the sea while crossing the Bay of Biscay. She also answered her helm admirably. Her officers are well satisfied with her performances, but they are unanimous in their condemnation of the heavy spars with which she is fitted. They reduce her buoyancy, handicap her engines, and are entirely useless for good in any way. A report to this effect will be made to the Admiralty, and there is every probability of their being superseded by military masts.

B. F. T.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOL. XIV, Nos. 6, 7 AND 8. Contain many interesting papers on torpedo boats. The observations at Polar station at Jan Mayen, 1882–83.

ANNALEN DER HYDROGRAPHIE.

PARTS V, VI, VII, VIII, IX. Contain interesting hydrographic and meteorological work of the German Navy.

SCHOOL OF MINES, COLUMBIA COLLEGE, QUARTERLY.

VOL. VII, JULY, 1886. The Rees rifle for military and sporting purposes, by Frank Rees.

This rifle is designed for the purpose of giving to the soldier and sportsman an arm which shall enable him to fire at will consecutive shots with the least possible effort or motion, and without the necessity of taking it down from the shoulder or disarranging the aim while reloading. The model used was fired thousands of times with ball and cartridge. At a recent trial before the officers of the 7th Regiment N. G. S. N. Y., fifteen shots were fired in 8 seconds actual time. J. W. D.

FRANKLIN INSTITUTE JOURNAL.

JULY, 1886. The applications of electricity to the development of marksmanship (O. E. Michaelis, U. S. A.).

AUGUST, 1886. The above concluded. Suggestions towards a simplified system of weather signals, termed the Index Weather-Signal System. A method of designing screw propellers. Christian Hoehle.

SEPTEMBER, 1886. The effect of inertia on the reciprocating parts in modifying the force transmitted to the crank pin (Francis E. Jackson, M. E.).

AMERICAN INSTITUTE OF MINING ENGINEERS.

VOL. XIV, FROM JUNE, 1885, TO MAY, 1886. The microscopic structure of iron and steel. The manufacture of steel castings. A simple apparatus for determining the strength of explosives. The homogeneity of open-hearth steel. Soft steel for boiler plates. The Heine safety boiler. Many other interesting papers.

PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS, LONDON.

MAY, 1886. On the raising of the wrecked steamship, Peer of the Realm.

HYDROGRAPHIC WORK OF THE UNITED STATES NAVY. BY LIEUTENANT A. B. WYCKOFF, U. S. N.

TRANSACTIONS OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST. MAY, 1886.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

Pile-driving, by E. H. Beckler. The work of the United States Testing Machine at Watertown Arsenal, by J. E. Howard.

ASSOCIATION PARISIENNE DES PROPRIETAIRES D'APPAREILS À VAPEUR. 12e Bulletin.

The above-mentioned publications are kept in the library of the Naval Institute. Members can obtain them for reference by applying to the Secretary.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1887.

A prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary, and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1887. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, to be published only with the consent of the author.

6. The subject for the Prize Essay is, *The Naval Brigade: Its Organization, Equipment, and Tactics.*

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

JNO. W. DANENHOWER,

Lieutenant, Secretary and Treasurer.

ANNAPOLIS, MD., *January* 1, 1886.

APPENDIX.

1886.

VOL. XII., NO. 1. WHOLE NO. 36.

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Iverson, A. J. Lieut.-Commander
Jackson, J. B. Ensign
Jacques, W. H. Lieutenant
Jasper, R. T. Lieutenant
Jayne, J. L. Ensign
Jenkins, T. A. Rear-Admiral
Jewell, T. F. Commander
Johnson, P. C. Commodore
Jones, H. W. Naval Cadet
Jones, W. H. Surgeon
Jouett, J. E. Rear-Admiral

Kafer, J. C. P. Asst. Engineer
Keilholtz, P. O. Naval Cadet
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King, W. R. Asst. Engineer
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McFarland, W. M. Asst. Engineer
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McLean, W. Lieutenant
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Miner, R. H. Ensign

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Nelson, V. S.	Ensign
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Niblack, A. P.	Ensign
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Nichols, H. E.	Lieut.-Commander
Nichols, S. W.	Commander
Nicholson, R. F.	Lieutenant
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Nixon, L.	Asst. Naval Const'r
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Norton, C. S.	Captain
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O'Neil, C.	Commander
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Rodgers, W. L.	Ensign
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Roller, J. E.	Lieutenant

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Street, G. W. Ensign
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Strong, E. T. Lieut.-Commander
Strong, W. C. Lieutenant
Sturdy, E. W. Lieutenant
Sullivan, J. T. Lieutenant
Sutphen, E. W. Naval Cadet
Talcott, C. G. Asst. Engineer
Taussig, E. D. Lieutenant
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Taylor, H. C. Commander
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Terry, S. W. Commander
Thackara, A. M., Esq. Philadelphia
Thomas, C. Lieutenant
Tilley, B. F. Lieutenant
Tilton, McL. Capt. U. S. M. C.
Totten, G. M. Lieut.-Commander
Train, C. J. Lieut.-Commander
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Turnbull, F. Lieutenant
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Turner, W. H. Lieutenant
Tyler, G. W. Lieutenant
Underwood, E. B. Lieutenant
Upshur, J. H. Rear-Admiral

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Veeder, T. E. D. W. Lieutenant
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Walker, J. G., Captain and Chief of Bureau of Navigation
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Wilson, Byron, Captain
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Wood, S. S. Ensign
Wood, W. M. Lieutenant
Woodbridge, W. E., Esq. Washington
Woodward, J. J., Asst. Naval Const'r
Woodworth, S. E. Ensign
Wooster, L. W. P. Asst. Engineer
Worden, J. L. Rear-Admiral
Worthington, W. F., P. Asst. Engineer
Wright, M. F. Lieutenant
Yates, A. R. Commander
Yates, I. I., Esq. Schenectady
Young, J. M. T. Capt. U. S. M. C.
Zane, A. V. P. Asst. Engineer

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Brown, A. D.,	Commander.	Prize Essayist, 1879.
Belknap, C.,	Lieutenant.	Prize Essayist, 1880.
Very, E. W.,	Lieutenant.	Prize Essayist, 1881.
Kelley, J. D. J.,	Lieutenant.	Prize Essayist, 1882.
Calkins, C. G.,	Lieutenant.	Prize Essayist, 1883.
Chambers, W. I.,	Ensign.	Prize Essayist, 1884.
Farquhar, N. H.,	Commander.	Prize Essayist, 1885.

Allen, R. W. Paymaster
Archbold, Saml., Esq., Member of Naval Advisory Board, Washington, D. C.
Barker, A. S. Commander
Bixby, W. H., Captain U. S. A.
Brown, Austin P., Esq., Washington, D. C.
Brush, G. R. Surgeon
Center, Robert, Esq. New York
Coryell, M., Esq. New York
Dayton, J. H. Lieut.-Commander
Delamater, C. H., Esq. New York
Denny, Wm., Esq., Shipbuilder, Dumbarton, Scotland
Elgar, Francis, LL.D. University of Glasgow
Evans, E. T., Esq. Buffalo
Evans, Robley D. Commander
Fletcher, A., Esq. New York
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Forbes, R. B., Hon. Milton, Mass.
Gardner, H. W., Esq. Providence
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Mason, T. B. M. Lieutenant
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Pond, C. F. Ensign
Quintard, G. W., Esq. New York
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Sibley College
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Ward, Aaron, Lieutenant
Watrous, Chas., Esq. New York
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U. S. Consul at Aspinwall.

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Zalinski, E. L. 1st Lieut. U. S. A.

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American Iron and Steel Association, Philadelphia, Pa.
American Metrological Society, Columbia School of Mines, New York City.
American Philosophical Society, Philadelphia, Pa.
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Connecticut Academy of Arts and Sciences, New Haven, Conn.
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Geographical Society of the Pacific, San Francisco.
Military Service Institution of the U. S., Governor's Island, N, Y.
School of Mines Quarterly, New York City.
Technical Society of the Pacific Coast, San Francisco, Cal.

Foreign.

Association Parisienne des Propriétaires d'Appareils à Vapeur, Paris.
Canadian Institute, Toronto.
Giornale d'Artiglieria e Genio, Rome.
Hydrographisches Amt der Kaiserlichen Marine, Berlin.
Institute of Mining and Mechanical Engineers, Newcastle-on-Tyne.
Institution of Civil Engineers, London.
Institution of Mechanical Engineers, London.
Mittheilungen a. d. Gebiete d. Seewesens, Pola.
Norsk Tidsskrift for Sovæsen, Horten, Norway.
Reunion des Officers de Terre et de Mer, Paris.
Revue Maritime et Coloniale, Paris.
Rivista Marittima, Rome.
Royal Artillery Institution, Woolwich.
Royal United Service Institution, London.
Société des Ingénieurs Civils, Paris.

NECROLOGY.

CLARK, LEWIS, Commander U. S. Navy. Born May 1, 1844, in Plymouth, Conn. Appointed to U. S. Naval Academy from Connecticut, September 24, 1861. Advanced to 3d Class, February, 1862. Appointed an Acting Ensign, October 21, 1863, and ordered to the U. S. S. Richmond, West Gulf Blockading Squadron. Battle of Mobile Bay, August 5, 1864. Attack on Spanish Fort and capture of Mobile, April 1865. Burned by explosion of torpedo off Mobile Point. Promoted to Master, May 10, 1866; to Lieutenant, February 27, 1867; and to Lieutenant-Commander, March 12, 1868. U. S. S. Ticonderoga, 1865-68. Naval Academy, 1869-72. U. S. S. Portsmouth, North Pacific Station, 1873-75. Torpedo Station, 1876. Granted one year's leave, 1877. U. S. S. Richmond, 1878-81. Commissioned a Commander, March 29, 1881. At Navy Yard, League Island, 1883. Ordered to command U. S. S. Alliance, July 5, 1884. Died on board the U. S. S. Alliance, at Key West, Florida, June 7, 1885.

GORRINGE, HENRY HONYCHURCH, late Lieutenant-Commander, U. S. N. Born in the Island of Barbadoes, West-Indies, August 11th, 1841. Son of an Episcopal clergyman who was nineteen years Rector of the windward part of the Island of Tobago. Resident of New York in his youth. Appointed an Acting Master's Mate in the Navy, June 22, 1862, for duty in the Mississippi Squadron. Served on the Tyler. March 31, 1863, promoted to Acting Ensign, and served on the Baron de Kalb. September 26, 1863, promoted to Acting Master, and ordered to command the Cricket. April 27, 1864, promoted to Acting Vol. Lieutenant for courage, zeal and ability displayed. January 16, 1865, detached from command of the Cricket and ordered to the North Atlantic Blockading Squadron. Commanded the Monticello. July 10, 1865, promoted to Acting Vol. Lieutenant-Commander. July 18, 1865, detached from command of the Monticello and

granted leave of absence. August 15, 1865, ordered to command the Boxer. November 6, 1865, detached and granted leave of absence. November 10, 1865, ordered to command the Waxsaw. January 4, 1866, detached and ordered to command the South Carolina, name changed to the Memphis. April 30, 1867, detached and placed on waiting orders. May 9, 1867, ordered to command the Guard. April 7, 1868, commissioned as Lieutenant in the regular service, to take rank from March 12, 1868. September 30, 1886, ordered to examination for promotion. October 15, 1868, detached from command of the Guard and ordered to Navy Yard, New York. December 8, 1868, detached and ordered to the Portsmouth, January 5, 1869. January 13, 1869, commissioned as Lieutenant-Commander to take rank from December 18, 1868. November 17, 1871, detached from the Portsmouth and placed on waiting orders. November 22, 1871, ordered to the Navy Yard, New York. January 4, 1872, detached and ordered to the Hydrographic Office 10th instant. November 18, 1873, detached and ordered to command the Pinta. May 6, 1874, detached from the Mayflower and ordered to the Hydrographic Office. August 31, 1874, detatched and granted one year's leave with permission to leave the United States. September 15, 1874, leave suspended and ordered to the Hydrographic Office. September 19, 1876, detached and ordered to command the Gettysburg. Detached May 28, and ordered to the Hydrographic Office, June 16, 1879. August 1, 1879, detached and granted six months' leave with permission to leave United States. January 20 1880, leave extended six months; July 23, 1880, leave extended six months; December 28, 1880, leave extended six months. During this leave of absence Mr. Gorringe interested New Yorkers in his project of bringing Cleopatra's Needle from Egypt to this country. With their financial aid he procured a suitable vessel, altered her for the special service of carrying the obelisk on a long voyage, and arrived safely with it in New York, July 20, 1880. This notable achievement in engineering was commended by the scientific men of America and of the world. A full account may be found in the work of Mr. Gorringe entitled *Egyptian Obelisks*, published 1882 by G. P. Putnam's Sons, New York. July 27, 1881, furlough granted six months; continued on furlough until his resignation was accepted February 21, 1883. After his resignation from the naval service Mr. Gorringe became the organizer and manager of the American Ship Building Company of Philadelphia.

During the winter of 1885 when going to the shipyard he jumped from a moving train, fell and injured his spine. He suffered many months from the accident and died in New York, July 7, 1885.

GRANT, ULYSSES S., General U. S. Army. Died, July 22, 1885, at Mount MacGregor, New York. General U. S. Grant was elected an honorary member of the Naval Institute, October 21, 1880. On October 23, 1880, General Grant accepted, and extended his thanks to the Institute.

KARNEY, THOMAS, late Professor U. S. Navy. Thomas Karney was born at Annapolis, Md., July 16, 1810. He was the son of Capt. Thomas Karney, a distinguished officer in the war of 1812, who was afterwards Auditor-General of the State of Maryland. Prof. Karney graduated at St. John's College in 1830; was admitted to the bar April, 1834, but never practised; was appointed Examiner-General of the State of Maryland, August, 1834, and held the office until 1850; was appointed Asst. Prof. of Ethics in the U. S. Naval Academy, October, 1851, and served in the Department of Ethics and the Department of Ethics and English Studies until September 20, 1870, when he was detailed to serve as Librarian, which position he filled with signal ability up to the time of his death, March 31, 1885, at Annapolis, Md.

MARSTON, JOHN, Rear-Admiral U. S. Navy. Born in Boston, 1796. Entered the Navy in 1813. Served on board the frigates President and Java; brig Prometheus; frigates Constellation, Constitution and Congress; frigate Brandywine, Commodore Chas. Morris, when she conveyed La Fayette to France. Served in the various squadrons on board frigate Brandywine, schooner Dolphin, sloop Vandalia, frigate United States, frigate Potomac and sloop Yorktown. Commanded sloop Cumberland at bombardment of Hatteras. Commanded frigate Roanoke at Hampton Roads when the Merrimac came down from Norfolk, Va., and attacked the fleet. Performed duty as Light House Inspector at Boston, and various duties at Portsmouth, N. H., and Philadelphia until retired. Promoted to Commodore July, 1862, and to Rear-Admiral in 1866. Died in Philadelphia, April 8, 1885, from old age and general weakness.

NYE, HAILE COLLINS T., Lieutenant U. S. Navy. Born, October 14, 1850, in Marietta, Ohio. Appointed to Naval Academy, July 28,

1866, and was graduated as Midshipman U. S. Navy, June 7, 1870. Served from September 1, 1870, until November 1, 1873, on board the U. S. S. California, Narragansett, Supply, Kansas and Richmond. May 19, 1874, was commissioned an Ensign U. S. Navy from July 13, 1872. Served in Coast Survey in 1874, '75 and '76. Commissioned Master U. S. Navy January 1, 1875. Ordered to U. S. S. Pensacola, October 23, 1876. Detached and ordered to Asiatic Station June 2, 1878, and served on board the U. S. S. Monocacy till April 5, 1881, when he was granted three months' leave, with permission to remain in Japan. From January, 1882, to December, 1883, served at Navy Yard, New York, and at torpedo instruction, Newport. Ordered to Shenandoah, December 18, 1883. Transferred to Monongahela October 17, 1884, and ordered to duty with Minister to Peru. January 27, 1885, ordered to return to the United States with the remains of the late Minister Phelps. Died at Lima, Peru, July 30, 1885.

PECK, RANSOME BYRON, Lieutenant U. S. Navy. Born November, 1843, at Oswego, N. Y. Appointed from Springfield, Mo., November 20, 1861, and was graduated in 1866. U. S. S. Guerriere, South Atlantic Station, 1867–8, and U. S. S. Kansas, same station, in 1869. Promoted to Ensign in April, 1868, to Master in March, 1869. Special duty at Jefferson Barracks, Mo., 1870. Commissioned Lieutenant, March 21, 1870. U. S. S. California, Pacific Station, 1871–2. U. S. S. Ticonderoga, North Atlantic Station, 1873–74. Naval Rendezvous, San Francisco, 1875–6. U. S. Flagship Pensacola, North Pacific Station, 1877–8. Detached August 14, 1879, and ordered to U. S. Hydrographic Office, October 25, 1879, and served there until April 29, 1882. During remainder of 1882 was at Torpedo Station, on board U. S. Gunnery Ship Minnesota, and as Executive Officer of Monitor Nantucket. December 16, 1882, ordered to Swatara. August 5, 1885, detached and granted sick leave for six months. Died November 6, 1885, while en route to Honolulu.

REMEY, EDWARD WALLACE, Lieutenant U. S. Navy. Born May, 1847, in Burlington, Iowa. Appointed to U. S. Naval Academy, September, 1862, and was graduated as Midshipman U. S. Navy, in June, 1867. Minnesota special cruise 1867–8. Promoted to Ensign in January, 1869. Served on board Onward. Promoted to Master, August, 1870. Served in U. S. Coast Survey. Promoted to Lieu-

tenant, January, 1874. Served on Ordnance and Torpedo duty, and at Hydrographic Office, in 1874. April, 1875, ordered to Tennessee, and served there until July, 1878. Ordered to Hydrographic Office October, 1878. September, 1879, took passage in the Constellation and joined the Trenton. Was detached October 31, 1881. Ordered to Tennessee, December, 1881, and was detached July, 1883, and ordered as Executive Officer of the training Ship Portsmouth. Left Norfolk on board an Old Dominion steamer, February 14, 1885, and arrived in New York, February 17, 1885. Not heard from since.

SCHOCK, JOHN LOOMIS, Assistant Naval Constructor, U. S. N. Born March 3, 1860, Schock's Mills, Penn. Appointed to U. S. Naval Academy, June 19, 1877, and was graduated June 10, 1881. Ordered to U. S. S. Quinnebaug, June 24, 1885, and transferred October 21, 1881, to the Royal Naval College, Greenwich, England. Appointed an Assistant Naval Constructor U. S. Navy, July 1, 1883. Remained at the College until his death, May 23, 1885.

SEMMES, ALEXANDER A., Commodore U. S. Navy. Born in the District of Columbia. Appointed a Midshipman in the Navy, October, 1841. Attached to frigate Columbus, Mediterranean Squadron, 1841–3. Skirmish with natives at Grand Bereby, Africa. Sloop Vincennes, East India Squadron, 1845–6. Naval School, 1847. Promoted to Passed Midshipman, August, 1847. Naval Observatory, Washington, 1849–50. Frigate Congress, Brazil Squadron, 1851–52. Coast Survey, 1853. Naval Observatory, Washington, 1854. Promoted to Master in 1855. Commissioned Lieutenant in September, 1855. Steamer Massachusetts, Pacific Squadron, 1855–7. In November, 1856, commanded a force of twenty-three sailors and marines in a successful attack upon an encampment of one hundred Russian-American Indians in Puget Sound. Powhatan, East India Squadron, 1859–60. Steamer Rhode Island, Atlantic Coast, 1861. Commanding steamer Wamsutta, South Atlantic Blockading Squadron, 1862–3. Engaged in a skirmish with the rebels at an island in Newport River, Georgia, April, 1862. Commanding gunboat Tahoma, East Gulf Blockading Squadron, 1863–4. Attacked the batteries of Tampa, Florida, April, 1863, and October, 1863, attacked the same batteries as a ruse while sending a party of sailors to capture some blockade-runners. September, 1863, while in command of light-draught steamer, made demonstration on Bayport, Florida, which

resulted in destruction of an English blockade-runner and the warehouse containing her cargo. Commanded ironclad Lehigh, 1864–5. Bombarding Fort Pringle, July 7–10, 1864. Picket duty in harbor of Charleston, S. C., during fall and winter 1864–5. February, 1865, commanded Lehigh, and was senior officer of six vessels operating against the rebel defences on James Island. Fall of Charleston, 1865. Commanded Lehigh in midnight bombardment of the Howlett House Batteries on James River. Fall of Richmond. Ordnance duty, Philadelphia, 1866–68. Commissioned as Commander, July, 1866. Commanded sloop Portsmouth, South Atlantic Station, 1869–71. Pensacola Navy Yard, 1872–74. Commissioned as Captain, August, 1873. Commanded Alaska, European Station, 1875–76. April 5, 1877, granted one year's leave, with permission to leave the United States, and continued on leave until October 15, 1880. September 10, 1880, ordered to Navy Yard, Washington, D. C., as Captain of the Yard. Detached April 13, 1882, and placed on waiting orders. Commissioned as Commodore to take rank from March 10, 1882. Appointed President of the Board of Inspection and Survey, September 29, 1882, and was detached June 30, 1883, and ordered to the command of the Navy Yard at Washington, D. C. Died at Hamilton, Virginia, September 22, 1885.

NAVAL INSTITUTE PRIZE ESSAYS, 1879–1887.

1879.

Subject:—"NAVAL EDUCATION.—I. OFFICERS. II. MEN."

Judges of Award:—CHARLES W. ELLIOT, President of Harvard University; DANIEL AMMEN, Rear-Admiral, U. S. N.; WM. H. SHOCK, Engineer-in-chief, U. S. N.

Winner of the Prize:—Lieutenant-Commander ALLAN D. BROWN, U. S. N. *Motto of Essay:*—"Qui non proficit."

First Honorable Mention:—Lieutenant-Commander CASPAR F. GOODRICH, U. S. N. *Motto of Essay:*—"Esse quam videri."

Second Honorable Mention:—Commander ALFRED T. MAHAN, U. S. N. *Motto of Essay:*—"Essayons."

Number of Essays presented for competition, ten.

1880.

Subject:—"THE NAVAL POLICY OF THE UNITED STATES."

Judges of Award:—Hon. WM. M. EVARTS, Secretary of State; Hon. R. W. THOMPSON, Secretary of the Navy; Hon. J. R. MCPHERSON, U. S. Senator.

Winner of the Prize:—Lieutenant CHARLES BELKNAP, U. S. N. *Motto of Essay:*—"Sat cito, si sat bene."

Number of Essays presented for competition, eight.

1881.

Subject:—"THE TYPE OF (I) ARMORED VESSEL, (II) CRUISER, BEST SUITED TO THE PRESENT NEEDS OF THE UNITED STATES."

Judges of Award:—Commodore W. N. JEFFERS, U. S. N.; Chief Engineer J. W. KING, U. S. N.; Chief Constructor JOHN LENTHALL, U. S. N.

Winner of the Prize by decision of two of the Judges:—Lieutenant EDWARD W. VERY, U. S. N. *Motto of Essay:*—"Aut Cæsar, aut nullas."

Recommended for the Prize by one of the Judges:—Lieutenant SEATON SCHROEDER, U. S. N. *Motto of Essay:*—"In via virtute via nulla."

Number of Essays presented for competition, four.

1882.

Subject:—"OUR MERCHANT MARINE; THE CAUSES OF ITS DECLINE AND THE MEANS TO BE TAKEN FOR ITS REVIVAL."

Judges of Award:—Hon. HAMILTON FISH, Ex-Secretary of State; JOHN D. JONES, President Atlantic Mutual Insurance Company, New York; A. A. LOWE, Ex-President New York Chamber of Commerce.

Winner of the Prize:—Lieutenant JAMES D. J. KELLEY, U. S. N. *Motto of Essay*:—"Nil clarius aquis."

First Honorable Mention:—Master CARLOS G. CALKINS, U. S. N. *Motto of Essay*:—"Mais il faut cultiver notre jardin."

Second Honorable Mention:—Lieutenant-Commander F. E. CHADWICK, U. S. N. *Motto of Essay*:—"Spero meliora."

Third Honorable Mention:—Lieutenant RICHARD WAINWRIGHT, U. S. N. *Motto of Essay*:—"Causa latet: vis est notissima."

Essay printed by request of John D. Jones, Esq.—Ensign W. G. DAVID, U. S. N. *Motto of Essay*:—"Tempori parendum."

Number of Essays presented for competition, eleven.

1883.

Subject:—"HOW MAY THE SPHERE OF USEFULNESS OF NAVAL OFFICERS BE EXTENDED IN TIME OF PEACE WITH ADVANTAGE TO THE COUNTRY AND THE NAVAL SERVICE."

Judges of Award:—Hon. ALEXANDER H. RICE; Judge JOSIAH G. ABBOTT; Rear-Admiral GEORGE H. PREBLE, U. S. N.

Winner of the Prize:—Lieutenant CARLOS G. CALKINS, U. S. N. *Motto of Essay*:—"Pour encourager les autres."

First Honorable Mention:—Commander N. H. FARQUHAR, U. S. N. *Motto of Essay*:—"Semper paratus."

Second Honorable Mention:—Captain A. P. COOKE, U. S. N. *Motto of Essay*:—"Cuilibet in arte suâ credendum est."

Number of Essays presented for competition, four.

1884.

Subject:—"THE BEST METHOD FOR THE RECONSTRUCTION AND INCREASE OF THE NAVY."

Judges of Award:—Rear-Admiral C. R. P. RODGERS, U. S. N.; D. C. GILMAN, LL. D., President of the Johns Hopkins University; Hon. J. R. HAWLEY, U. S. Senator.

Winner of the Prize:—Ensign W. I. CHAMBERS, U. S. N. *Motto of Essay*:—"Thou too, sail on, O Ship of State."

Number of Essays presented for competition, two.

1885.

Subject:—"INDUCEMENTS FOR RETAINING TRAINED SEAMEN IN THE NAVY AND THE BEST SYSTEM OF REWARDS FOR LONG AND FAITHFUL SERVICE."

Judges of Award:—Rear-Admiral THORNTON A. JENKINS, U. S. N.; Commander W. S. SCHLEY, U. S. N., Chief of Bureau of Equipment and Recruiting, Navy Department, Washington, D. C.; and Captain JOHN CODMAN, of New York City.

Winner of the Prize:—Commander NORMAN H. FARQUHAR, U. S. N. *Motto of Essay:*—"Ut prosim."

Number of Essays presented for competition, three.

1886.

Subject:—"WHAT CHANGES IN ORGANIZATION AND DRILL ARE NECESSARY TO SAIL AND FIGHT MOST EFFECTIVELY OUR WAR SHIPS OF THE LATEST TYPE?"

Judges of Award:—Rear-Admiral E. SIMPSON, U. S. N., President of Board of Inspection; Captain MONTGOMERY SICARD, U. S. N., Chief of Bureau of Ordnance; and Captain AUGUSTUS P. COOKE, U. S. N., Commanding U. S R. S. Vermont.

Number of Essays presented for competition, seven.

These essays are now in the hands of the Judges, and the award will soon be made.

1887.

Subject:—"THE NAVAL BRIGADE—ITS ORGANIZATION, EQUIPMENT AND TACTICS."

All essays on the above subject to be sent in sealed envelopes to the Secretary and Treasurer, on or before January 1st, 1887.

PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

ANNAPOLIS, MD.

Organized October 9th, 1873, at the U. S. Naval Academy.

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ANNUAL REPORT OF THE SECRETARY AND TREASURER.

To the President, Officers and Members of the Institute:

Gentlemen:—I have the honor to submit the following report of the financial transactions for the year 1885, as deduced from the accounts of the three gentlemen who have held office during that year.

The cash statement is as follows:

Receipts.

Balance on hand January 1, 1885, per report,		$ 427 79
From dues,		1961 53
From back numbers, returned and credited to dues,		4 00
From life-membership fees (11),		330 00
From subscriptions,		613 90
From sales of publications,		772 14
From extra binding,		38 75
From interest on bonds,		69 50
From premium on exchange,		15
		$4217 76

Expenditures.

For postage, freight, telegraphing and incidental expenses at headquarters,	$ 274 64	
For messenger at headquarters,	295 83	
For stationery at headquarters,	51 86	
For expenses of Branches,	35 47	
For printing publications, &c.,	2812 56	
For copyright fees,	4 00	
For advertising,	20 00	
For purchase of back numbers,	8 75	
For Prize Essay for 1885,	100 00	
For engraving medal,	1 00	
		3604 11
Balance on hand January 1, 1886,		$ 613 65

Of this balance the sum of $206.12 belongs to the Reserve Fund to be invested as soon as practicable.

Bills outstanding—Printer's bill, No. 35, not yet rendered, probably amounts to $600.00.

Bills receivable—Outstanding dues for 1884 and 1885,	$700 00
Publications sold late in December, 1885,	200 00
Total, ...	$900 00

The Reserve Fund.

This fund consists of the life membership fees and of certain surplus that has from time to time accumulated. During the year 1885 one United States 4 per cent. bond was purchased at $123.88, and there now remains the sum of $206.12 to be invested and credited to the Reserve Fund, which is to be held in perpetuity to guarantee the future interests of the Institute and of the life members in particular. The following bonds are now deposited in the vault of the Farmers' National Bank of Annapolis for safe-keeping, viz.:

Eight (8) United States 4 per cent. of face value $50 each = $400; five (5) United States 4 per cent. of face value $100 each = $500; total face value $900. Market value $1108.10; New York quotation January 1, 1886, $1.23¼; interest payable quarterly from January 1; bonds run till 1907.

Two (2) District of Columbia 3.65 per cent. bonds of face value $500 each = $1000. Market value $1170; Washington quotation January 1, 1886, $1.17; bonds run till 1924; interest payable semi-annually, February and August.

Total face value of bonds, $1900; total market value, $2278.10.

Membership.

The total membership of the Institute now stands as follows:

Regular members, ...	580
Associate members, ...	121
Life members	60
Honorary members	8
Total membership January 1, 1886, . .	769
Total membership January 1, 1885, . .	763
Net increase, ...	6

During the year 1885.

	Regular Members.	Associate Members.	Life Members.	Honorary Members.
Died,	7	0	1	1
Dropped,	14	0	0	0
Resigned,	23	5	0	0
Transferred to life members,	5	0	...	...
Joined,	28	19	7	...

PUBLICATIONS.

The Institute has on hand back publications as follows;

	Copies Plain.	Copies Bound.
No. 1	199	...
" 2	253	...
" 3	80	...
" 4	170	...
" 5	138	...
" 6	22	...
" 7	28	...
" 8	52	...
" 9	58	...
" 10	15	...
" 11	233	...
" 12	52	...
" 13	12	...
" 14	10	...
" 15	none.	...
" 16	238	...
" 17	none.	...
" 18	67	...
No. 19	126	...
" 20	135	...
" 21	218	...
" 22	297	...
" 23	210	...
" 24	218	...
" 25	110	48
" 26	234	74
" 27	306	27
" 28	none.	6
" 29	318	26
" 30	262	6
" 31	150	58
" 32	none.	190
" 33	32	146
" 34	109	102
" 35	190	72

The archive set, complete in twelve volumes, bound in full turkey, and nine copies of Vol. X., in two parts, bound in half-turkey.

In conclusion, I beg to state that the business affairs have increased so much in detail and importance that the best interests of the Institute demand the services of an individual who can devote his entire time to the work, and I respectfully suggest that an officer be specially detailed for this position.

JNO. W. DANENHOWER, LIEUT. U. S. N.,
Secretary and Treasurer.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1887.

A Prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1887. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the Proceedings of the Institute, and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, to be published only with the consent of the author.

6. The subject for the Prize Essay is, *The Naval Brigade: Its Organisation, Equipment and Tactics.*

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

JNO. W. DANENHOWER,
Lieutenant, Secretary and Treasurer.

ANNAPOLIS, MD., *January* 1, 1886.

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NOTICE.

The U. S. Naval Institute was established in 1873, having for its object the advancement of professional and scientific knowledge in the Navy. It now enters upon its fourteenth year of existence, trusting as heretofore for its support to the officers and friends of the Navy. The members of the Board of Control cordially invite the co-operation and aid of their brother officers and of others interested in the Navy, in furtherance of the aims of the Institute, by the contribution of papers and communications upon subjects of interest to the naval profession, as well as by personal support and influence.

On the subject of membership the Constitution reads as follows:

ARTICLE VII.

SEC. 1. The Institute shall consist of regular, life, honorary, and associate members.

SEC. 2. Officers of the Navy, Marine Corps, and all civil officers attached to the Naval Service, shall be entitled to become regular or life members, without ballot, on payment of dues or fee to the Secretary and Treasurer, or to the Corresponding Secretary of a Branch. Members who resign from the Navy subsequent to joining the Institute will be regarded as belonging to the class described in this Section.

SEC. 3. The Prize Essayist of each year shall be a life member without payment of fee.

SEC. 4. Honorary members shall be selected from distinguished Naval and Military Officers, and from eminent men of learning in civil life. The Secretary of the Navy shall be, *ex officio*, an honorary member. Their number shall not exceed thirty (30). Nominations for honorary members must be favorably reported by the Board of Control, and a vote equal to one-half the number of regular and life members, given by proxy or presence, shall be cast, a majority electing.

SEC. 5. Associate members shall be elected from officers of the Army, Revenue Marine, foreign officers of the Naval and Military professions, and from persons in civil life who may be interested in the purposes of the Institute.

SEC. 6. Those entitled to become associate members may be elected life members, provided that the number not officially connected with the Navy and Marine Corps shall not at any time exceed one hundred (100).

SEC. 7. Associate members and life members, other than those entitled to regular membership, shall be elected as follows: Nominations shall be made in writing to the Secretary and Treasurer, with the name of the member making them, and such nominations shall be submitted to the Board of Control, and, if their report be favorable, the Secretary and Treasurer shall make known the result at the next meeting of the Institute, and a vote shall then be taken, a majority of votes cast by members present electing.

The Proceedings are published quarterly, and may be obtained by non-members upon application to the Secretary and Treasurer at Annapolis, Md. Inventors of articles connected with the naval profession will be afforded an opportunity of exhibiting and explaining their inventions. A description of such inventions as may be deemed, by the Board of Control, of use to the service, will be published in the Proceedings.

Single copies of the Proceedings, $1.00. Back numbers and complete sets can be obtained by applying to the Secretary and Treasurer, Annapolis, Md.

Annual subscription for non-members, $3.50. Annual dues for members and associate-members, $3.00. Life membership fee, $30.00.

FORM OF BEQUEST.

I give and bequeath to the Association known as the UNITED STATES NAVAL INSTITUTE, organized October, 1873, at Annapolis, Md., the sum of..... dollars, to be applied to the uses and purposes of said Association.

If real estate is bequeathed, describe it.